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EDITORIAL

RECENT DEVELOPMENTS AT I.C.T.A.

THE YEAR 1950, has been one of unprecedented development at the Imperial College of Tropical Agriculture. Many new members of the staff have taken up their duties and the building scheme is nearing completion. The Departments of Botany and Plant Pathology, and Entomology and Zoology have already moved into the commodious new Biology Laboratories. The members of the Sugar Research Scheme have at last been able to transfer their activities from Birmingham University to the new Sugar Research Laboratories in Trinidad. The completion of these two modern Laboratories has released space for other overcrowded Departments of the College. The old Biology Building, which once housed all the Administrative and Academic Departments of the College, will soon become the headquarters of the College Department of Agriculture and the scene of most of the class-room teaching. The transfer of the Department of Agriculture from the Main Building will permit the Library and Publications Department to occupy the whole of the first floor. The rapidly expanding Department of Soil Science and Chemistry now occupies the whole of the Chemistry Building which it previously shared with the Department of Sugar Technology.

This expansion has been necessitated by the allocation of four large research Schemes to the College. The Banana Research Scheme has as its main object the breeding of a banana possessing the valuable commercial characteristics of the Gros Michel variety but which is resistant to Panama and other diseases which now threaten the industry. The comprehensive nature of the Cocoa Research Scheme may be gauged by the fact that it provides for the appointment of plant breeders, plant physiologists, a biochemist, soil chemists, an entomologist and a plant pathologist. The College has long been a centre of cocoa research and the work of its scientists has already borne abundant fruit. The development of a vegetative means of propagation coupled with the selection of trees of outstanding merit have improved out of all recognition the commercial prospects of the industry. The demands for cuttings of I.C.S. (Imperial College Selection) clones in Trinidad and Tobago alone already exceed one quarter of a million annually. These achievements, spectacular as they are, represent merely a beginning and much remains to be accomplished.

The objects of the Sugar Research Scheme have been defined thus : " To advance factory technique and efficiency by technological investigation and fundamental research and to investigate what new products may be made from sugar cane, its direct products and its by-products, and to examine the possibilities of their manufacture ". Progress has already been such as to warrant the erection of a pilot plant in which the problems of manufacturing new products on a commercial scale will be investigated. The long-term results of this research scheme may well prove to be revolutionary.

The Soils Research Scheme is designed to improve our knowledge of the soils of all territories in the British Caribbean, with particular reference to their agricultural utilization. Surveyors are already at work in Jamaica and British Honduras, and although the programme must of necessity occupy many years, its importance to the overcrowded West Indian agricultural populations can hardly be exaggerated.

The Imperial College of Tropical Agriculture has become, in effect, the central agricultural research institution for the British Caribbean, and more and more of its resources will be devoted to research. But its teaching and training facilities have not been neglected. The concentration of a large number of research workers at the College will in itself greatly enhance its value as a centre for Post Graduate specialist training. Moreover, the development of the New College Farm at St. Joseph will at long last provide our Agricultural Department with those land facilities essential for the teaching and demonstration of practical agriculture. Thus, in respect of both research and teaching, the College has made a notable stride forward during 1950.

REVIEW ARTICLES AND BOOK REVIEWS

RESEARCH, COLONIAL AGRICULTURE AND INDUSTRY

AGRICULTURAL RESEARCH

BY

H. J. PAGE

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A paper presented at the West Indian Conference (Fourth Session) of the Caribbean Commission, at Curacao on 4th December, 1950.

BEFORE we commence to consider agricultural research in relation to the economy of the Caribbean region, or indeed agricultural research in its wider and more general aspects, it is essential that we shall be clear as to what exactly we understand by " research ".

In the dictionary you will find research defined as " methodical and original enquiry into, or study of, some subject by trained investigators, in order to add materially to existing knowledge of, or to furnish new ideas upon, that subject ". This very broad definition includes other kinds of research besides what most people mean by scientific research ; for example, it would include a study of historical records and the bringing to light of facts in those records which are not common knowledge ; or the study and analysis of trade statistics. In the field of agriculture as in many others, such kinds of research may furnish information or new ideas of the greatest value in agricultural development and planning. But nowadays by research most people mean *scientific* research ; at any rate, that is what is usually understood by agricultural research : the experimental and observational application of the sciences to the study and practice of agriculture :— chemistry, physics, geology, botany, zoology, physiology, economics and so on. It is with agricultural research in this aspect that this paper is chiefly concerned.

Agriculture itself is *not* a science ; it is an art—the oldest of the arts—an industry, a way of life. But the *processes* that go on in the formation, and cultivation of the soil, the growing of crops, the raising of livestock—in all the many and varied branches of husbandry,—are all subject to the natural laws with which the sciences I have just mentioned are concerned. Agricultural science is in fact a complex of subjects each related to one of these separate sciences : agricultural chemistry, agricultural botany, agricultural economics, and so on.

Scientific research is commonly divided into two parts : *Pure*, or *fundamental* research, and *applied* research. The former, fundamental research,

used to be understood to mean research having for its object the acquisition of knowledge purely for its own sake, entirely without any thought as to possible practical utilisation of the results. When Rutherford was studying the structure of the atom he was not trying to find out if the atom bomb was possible ! Applied research, on the other hand, is research which is avowedly utilitarian in its objects. However, it is now recognised that because research is being carried out with utilitarian objects, it may still be fundamental. This is notably true in the case of agricultural research, which by its very name is a branch of industrial research and therefore wholly a branch of what has been called applied research. Appleton has recognised this by defining fundamental research as of two kinds—*pure-fundamental* and *applied-fundamental*. A study of the chromosomes and the genetics of the banana is just as fundamental as a study of the chromosomes and genetics of, say, the jellyfish. But whilst the latter might well be the research topic of a university professor quite uninterested in the practical value of jellyfishes (if indeed they have any), and so classified as pure-fundamental research, the study of the cytogenetics of the banana, though no less recondite than that of the jellyfish, and needing just as high a degree of skill and specialisation, may well be (and is) being made in the hope that it will help to show how improved varieties of banana can be produced for use as human food—what Appleton would call applied-fundamental research.

I prefer to think of research problems and projects more in terms of targets and range to those targets. So-called pure-fundamental research is research which has no specific target, it is unaimed research (which does not mean that it is aimless !). Research carried out for a specific object is *aimed* research, research aimed at a definite target. To pursue the metaphor, the target may be near or distant, i.e., the research may be *short-range or long-range* research. The study of the cytogenetics of the banana in the hope that it will help in the breeding of improved varieties is long-range research, but investigations to find out, for example, which fungicide is best for controlling the leaf spot disease of bananas is short-range research.

I have chosen agricultural examples in these illustrations in order to get back from what may have seemed to be a rather academic discussion to the real subject of this paper—agricultural research. Having postulated that all agricultural research is by definition what is commonly known as applied research, or what I call *aimed* research, we can divide it into two classes :—

Long-range research ; and
Short-range, (or *ad hoc*) research.

Can we find a simple and straightforward means of classifying agricultural research under these two heads ? I think we can, if we remember that the *things* from which agricultural materials are got, namely the rocks and minerals from which the soil is derived, and the plants or animals which are the source of agricultural products, are specific entities in themselves, but that the *conditions* under which soils are formed and crops and stock are raised, are widely variable, embracing variations in geology, climate, economic conditions and so on. I would classify as *long-range research* on the above definitions, all work which is concerned with the *instrinsic* nature and properties of the materials, plants, and animals with which agriculture is concerned ; *short-range research*, within the above definitions, on the other

hand, consists in the study of how the results of long-range research will vary, and can be practically applied, under given local conditions. To take only a few examples at random : a study of the factors concerned in causing soil erosion is long-range research, but a study of how the knowledge so gained can be used to prevent soil erosion in a given locality, having regard to the kind of soil and to the topographical, climatic and farming conditions there obtaining, is short-range research. Similarly, a study of the life history and feeding habits of termites is long-range research, but the use of this knowledge to investigate how the ravages of a given species of termite can be prevented in given circumstances is short-range research. Again, investigations on the conditions favourable to the retention of viability of sperm is long-range research, but the working out from this of conditions for the transportation of sperm to distant localities and its use there for artificial insemination, is short-range research. These few random examples will no doubt suggest many others to you, and if you analyse them you will find that the so-called short-range investigations are all concerned with the application in agricultural practice, of fundamental, *basic* knowledge about the instrinsic nature of things and processes, under the conditions of soil, climate, &c., obtaining at the place where it is to be applied. This is research into the *technology* of the practical application of science to agriculture. Conditions of soil, climate, &c., vary enormously : many crops or breeds of stock which thrive in the temperate zone are quite useless in the tropics, and vice versa. This is an extreme and self-evident example, but within quite short distances differences in soil, or in rainfall, or other factors, may result in radical differences in the system of husbandry which can best be practised with profit, or in the need to grow different varieties of the same crop in different places : for example, some varieties of sugar cane which are first-class in some parts of the Caribbean are quite inferior in others.

The study of the interaction of living things, plants or animals, with their environment is called Ecology, and the above examples are all instances of applied ecology*. We thus arrive at what I have adopted in the remainder of this paper as the most useful classification of agricultural research. What has been called above fundamental or long-range research I call *Basic Research*, whilst what has been called applied, ad hoc, short-range research I call technological-ecological, or, for short, *Techno-ecological Research*, or even, to coin one of the portmanteau words which are so fashionable nowadays, *Technecological Research*.

It would be out of place to attempt here an analysis and description of all the various branches of basic and techno-ecological agricultural research, and to consider in detail their relative importance in the Caribbean region. That excellent publication of the Caribbean Commission, the "Year Book of Caribbean Research" gives detailed information, and in the "1949 Supplement" which is wholly devoted to agriculture, fisheries and forestry, research projects in agriculture are dealt with under 16 subject sub-headings. To get some idea of the relative proportions in which Basic and Techno-ecological research are represented in this survey, I have classified all the

* Professor Hardy in his paper "Soil Productivity in the British Caribbean Region" presented at an earlier session of this Conference gives a detailed discussion of the ecological factors comprised in soil conditions and climate and their bearing on soil productivity in the Caribbean region.

projects listed, as closely as the published information allows, under these two headings, omitting these projects for which the classification is doubtful, and others which are practical development rather than research projects. This classification shows that, out of a total of 399 projects, 27 are Basic and 372 Techno-ecological, a ratio of 1 to 14. There is nothing surprising in this ratio. Experiments in many different localities are needed to study the application of a given basic fact under widely varying combinations of soil, climate, &c. These figures illustrate, however, the contrast between intensive, centralised basic research and extensive, scattered techno-ecological research, and the very much greater demands made by the latter on personnel and related sources.

By its very nature, basic research, which requires the highest degrees of training, skill and experience, and the most complete and up-to-date equipment, can usually be carried out only at specially organised research centres and by comparatively few picked men. Techno-ecological research, on the other hand, is of necessity scattered widely throughout the Region, for the possible application of the results of basic research *must* be studied in the localities where it is desired to apply them in practice, and it must be carried out mostly by the rank and file of the technical staff. Thus basic research is primarily the function of regional or national research organisations whilst techno-ecological research is primarily the function of the local departments of agriculture and similar local bodies. But it is of the utmost importance that there shall be the closest co-ordination between the two. Not only must the basic information to be applied, and its implications, be fully understood, but the local experiments at various places must so far as possible form parts of a co-ordinated scheme designed to get the greatest possible information out of the resources available. Moreover, modern methods of experimentation in agriculture are often elaborate and tricky, needing very specialised advice in their design and execution and in the analysis and interpretation of their results. The effective achievement of this co-ordination between local departments and authorities on the one hand, and central bodies under higher control on the other involves possibilities of all sorts of political and administrative difficulties even within one national group, and they may be much greater on the international basis.

Nevertheless, it would be difficult to exaggerate the vital importance of developing this extensive techno-ecological experimental work very much more widely and actively than at present.

The improvement of the standard of farming and with it the prosperity of a Region with an economy overwhelmingly dependent on agriculture, by the practical application of new scientific knowledge obtained by basic research, requires a large and well-organised extension service. The methods and aims of such a service, and its requirements, have been fully discussed at an earlier meeting of this Conference. But the essential requirement, without which an extension service is useless, is accurate well-founded knowledge to "extend". Techno-ecological research and experimentation is an essential link between basic research and knowledge at one end of the chain and extension work at the other. The incongruity of pursuing the military metaphor of targets used earlier in this paper, in relation to a peaceable industry like agriculture, is excusable in this war-torn age. An

extension service without a commensurate organisation of techno-ecological research and experimentation is like an army with weapons but no ammunition. Basic research supplies the high explosive, but by itself it is as little use for extension work as TNT in bulk would be for use in rifles or artillery. The extension worker must know, from well-conducted experiments on the spot, under the actual conditions of soil, climate, &c., there prevailing, how the available basic knowledge can be effectively applied for the benefit of the farmers of the locality. What I have termed techno-ecological research, as a description of the *nature* of the work and problems involved, might well be termed "extension research" as a definition of its *purpose*. It is this kind of agricultural research for which there is a crying need. The ratio of 14 "extension research" projects to one "basic research" project, disclosed by the Year Book of Caribbean Research, is not nearly high enough. It should be more like 100 or higher, and the work should be much more organised and co-ordinated. But this is practicable only by getting many more trained men, not only for extension-research and experimental work, but for extension work itself. In the British Caribbean colonies, at any rate, the establishments of suitably trained staff for such work are far too small, and, to make matters worse, many of the posts in those establishments are unfilled. Unless this state of affairs can be remedied there is little hope of getting marked improvements in agricultural practice by the application of science to agriculture on a wide enough scale to bring about a general raising of the prosperity of the agricultural community of the Region.

This conclusion does not apply to large commercial enterprises (such as sugar companies) : these have the resources and leadership to look after themselves in this respect ; they can afford to employ well-trained men for their own techno-ecological experimentation ; and their extension work depends purely on themselves and is wholly under their own control.

It is the small, individually financed and operated, privately-owned estates, and above all, the peasantry, representing the bulk of the farming community, who need assistance from a publicly-financed research and extension service ; and even when such assistance has been afforded them, and has convinced them of the potential benefits within their grasp, they are more often than not unable to take advantage of it without public financial assistance, of which the Trinidad Cocoa Subsidy scheme is a notable example.

Schemes for agricultural betterment involving the application of modern scientific knowledge by "extension research" and by extension work, are of two kinds :—

(*a*) those for the benefit of *existing* farming enterprises—small proprietary undertakings, and the peasantry ; in such schemes far more attention needs to be given to subsistence crops : increasing the production of home-grown food ; and

(*b*) development schemes for enlarging the area devoted to economic crops and stock ; here "pilot schemes" carefully planned at high administrative and technical levels should be a dominant factor. In planning such schemes, careful land-use surveys must be made, including a close study of ecological, climatological and topographic factors and a consideration of available markets

and communications. In the past it has been far too common for development schemes to be established without such a survey, only to find too late, after much money and effort have been spent, that the local conditions of soil, climate, &c., are not suitable, and the scheme a failure. The best available technical and scientific advice must be utilized. Only in this way can full advantage be taken of available scientific knowledge and good prospects of success be assured. It would be otiose now to instance the East African Groundnut Scheme as an example of what can happen when things are not done in this way.

Before the adequate, greatly expanded research and extension services needed for the proper application of science to agriculture can be got, much more money is needed, and many more trained men must be available. The supply of science graduates from British universities has been much less than the demand since the war. There are signs that this state of affairs is now passing and that before long there will be more young chemists, biologists, economists, &c., than jobs ; but it will take at best several years before men so recruited can be trained for the adequately expanded research and extension services, and then only if the necessary extra funds are forthcoming.

The most we can do in the immediate future is to see that the available men and money are used to the best advantage. This raises the question of priorities. I have not the slightest doubt in my own mind that in deciding such priorities, for the present, basic research must take second place to techno-ecological or " extension " research and to extension work itself, so far as concerns the use to be made of further available resources of trained men and money, so long as these are in short supply. In Agriculture, as in most other industries the amount of basic knowledge available is far ahead of the use which is being made of it.

In expressing this view, I am in very distinguished company. In his presidential address to the British Association for the advancement of Science, in 1948, Sir Henry Tizard, K.C.B., F.R.S., chief scientific adviser to the British Government, said " it is not the general expansion of research in this country that is of first importance . . . . . *What is of first importance is to apply what is already known.* The fact is that all really new developments of industry are the product of the work of very few men. In general, knowledge in the physical sciences now accumulates at a rate much faster than it is, or possibly than it can be, applied in industry. *There is a vast amount of knowledge waiting to be used. No new discovery, in any field, is likely to have so quick and beneficial an effect on British industry as the application of what is already known.*" At the same meeting the President of the Agricultural Section, (the late) Dr. G. Scott Robertson, said " Our great advantage lies in the startling, the incredible advance of science during the 150 years of plenty, and in the fact that the new knowledge and vastly increased power and resources which it has given us and continues to give us have, in the realm of agricultural science, *only been applied and then very inadequately to a small portion of the potential crop-producing soils of the world.* If a peaceful world were to set itself the task of *applying the knowledge we already have* . . . . it would, at a very conservative estimate, be possible to double and even treble our production of food in a relatively short time.". The italics in these questions are mine.

In these circumstances, with not nearly enough money or trained men to go round, there is a real need for some sort of permanent advisory council, composed of both technical men and administrators, to survey constantly the economic problems facing the farmers of the Caribbean Region, to indicate which of them can be tackled by the application of agricultural science, and *to assign priorities* so that first things come first and limited resources in men and money are put to the best use. Such advisory councils would no doubt have to be established primarily on a national rather than an all-Caribbean basis, but the Caribbean Commission could play a most important part in fostering their establishment in the Caribbean territories of its four member nations and in linking up and integrating their work.

ECONOMIC POTENTIAL OF COLONIAL AFRICA

(*Condensed from an address by Mr. Frank Samuel, Manager of the United Africa Company Ltd. to the Royal Empire Society Summer School at Ashridge, published December*, 1949)

Introduction

I AM going to try to indicate the economic possibilities of an area of tropical Africa twice as large as the combined areas of France, Germany and Great Britain ; with a population of between 40 and 50 millions of Africans ; and an export trade which has in recent years averaged £89 millions annually.

The area I am going to speak about comprises Nigeria, the Gold Coast, Sierra Leone and the Gambia in the West ; and Uganda, Tanganyika and Kenya in the east. Of this whole area only parts of Kenya and Tanganyika are suitable for white settlement. So for the most part I shall be discussing African Africa.

The history of British Tropical Africa in the nineteenth century is one of the gradual imposition of law and order upon warring tribes ; of the eradication of barbarous practices ; and of the suppression of slavery.

Thus up to fifty years ago, broadly speaking, only the very first steps had been taken to bring civilizing influence to bear on the primitive inhabitants of this vast area. Rapid economic progress has been made possible since the beginning of this century largely as a result of Europe's discovery of the means of utilizing the agricultural and forest produce of tropical countries.

The task of Colonial Administrators has been immense. They have had to administer territories where, as one writer has aptly put it, in the space of fifty years ' the twentieth century after Christ has been superimposed on the twentieth century before Christ '. The degree of individual effort required to bring about this transformation will perhaps be better realized if I tell you that, leaving aside Kenya, where there are over 30,000 European settlers, the total number of Europeans in British Tropical Africa does not exceed 25,000—or one European to every 1,600 Africans.

Superficially, there is perhaps a great similarity in the progress of India and Africa, but fundamentally there is none. In India, modern commerce and science were grafted on to an advanced civilization much older than our own. In Africa, there is no grafting. There is impact. The impact of the Atomic Age upon the Stone Age. The great Indian Empire of Asoka flourished 2,200 years ago. There is no parallel for this in Africa.

Were it not for the export of capital goods from this country, achievement in Africa would have been insignificant. How would the groundnuts, and minerals of Nigeria have been exported without adequate rail transport ?

How would Nigeria's coal have been moved without a railway from Enugu, and port facilities at Port Harcourt ? How would the produce of Uganda and Kenya have been exported without the Uganda-Kenya railway ? How would the minerals of the Gold Coast have been moved without the port installations of Takoradi ?

Even now, the cost of transport is the primary element in the economic possibilities of the more remote regions. For example, cement delivered in Maiduguri in Northern Nigeria costs nearly £20 a ton, one half of which represents transport costs. In Maiduguri, the producer is paid £13. 13*s*. 9*d*. a ton for his groundnuts : to bring these to the United Kingdom costs just over £14 a ton for transport alone. To put the point another way : one ton of groundnuts in the United Kingdom will buy nine tons of cement ; whereas in Maiduguri it will buy only two-thirds of a ton of cement.

Having thus briefly sketched in some of the background features, I come to the main theme of my paper.

Whilst most of what I have to say will deal with prospects for the future, it is, I feel, important to touch briefly on the degree of economic development which has been achieved up to now. I will refer first to the progress of agricultural and mineral production in the first forty years of the century, which witnessed the great initial spurt in the development of tropical Africa.

The outstanding achievements of those years can, I fear, only be illustrated by figures. I can think of no other way of measuring the great upsurge in the economic life of tropical Africa in the period we are considering.

Past Achievements

Agricultural and Mineral Production 1900–1939

Nigeria is the largest and most important of the territories of Tropical Africa. In 1900, Nigeria's exports of palm kernels, groundnuts, cocoa, hides and skins and tin were negligible. By the outbreak of the last war, exports of these commodities had reached a maximum annual value of £14 millions. In the same period, exports of palm oil more than trebled, both in volume and value.

Perhaps the significance of these great increases in production—most of which, as you probably know, were due to the initiative of the peasant himself—will become clearer if I tell you that the production for export of 300,000 tons of groundnuts in Northern Nigeria in 1936 meant the cultivation of over one million acres of land. This must have been undertaken by about a million peasant farmers, each placing about one quarter of his 4 or 5 acre farm under groundnuts. The average size of an African family is certainly over 4, so that 300,000 tons of groundnuts represents the economic surplus of over 4 million people. I wish I had time to tell you how the surplus of each small farmer is collected, paid for, made up into larger lots, and transported to the ports over 700 miles away. It is a fascinating story.

In the Gold Coast, there was virtually no production of cocoa in 1900. By 1936, cocoa exports had reached the remarkable figure of 311,000 tons valued at £8 millions. Here again, this growth is significant. It means that within forty years over 300,000 peasant farmers had planted—largely on their own initiative —perhaps 1¼ million acres of cocoa, and that over 1½ million people were directly dependent on a monoculture.

The strength of the urge to extend cultivation can also be seen in Uganda, where in only 20 years—from 1916 to 1936—the acreage under cotton, which, like cocoa, is a cash crop, increased from 133,000 acres to 1,500,000 acres.

1939–1949

Let us now examine the progress in the same field since 1939. One thing is clear : production, whether agricultural or mineral, has not increased at anything like the same rate as in the previous forty years. Generally speaking, the volume of agricultural production is now no greater than the maximum attained just before the war, but its money value has risen enormously. For example, the total tonnage of exports of cocoa, groundnuts, palm oil and palm kernels from Nigeria and the Gold Coast is a little below the maximum pre-war export figures : but its cost has almost quadrupled, being now about £67 millions.

The effect of these rises in price has been to mask altogether the true economic situation. Broadly speaking, the Tropical African countries have just about maintained the position they had reached at the outbreak of war.

But a further effect of the rise in values has been the erection of an artificially high level of Government income and expenditure. Government revenues are mainly derived from import and export duties, and tax on trading profits. Comparing the position now with the three years immediately preceding the war, there has been as I mentioned before a four-fold rise in produce prices. But the cost of Government has risen even more. For instance in the years 1936 to 1938 the annual average of the budgets of the four British West African territories totalled £11 millions. The latest budget figures total some £55 millions, a five-fold increase. I will refer again to this subject later.

Communications and Ports—1900–1949

Communications and means of transport are the *sine qua non* of production for export. And the progress of communications in Tropical Africa since the beginning of the century has been even more striking than the increase in production.

In the whole of the seven territories of British Tropical Africa, there were in 1900 only 32 miles of railway in operation. Today, there are 3,000 miles of line in British West Africa, which cost £33 millions ; while in East Africa there are 3,000 miles of railway where fifty years ago there were none.

Those who have travelled through southern Nigeria by road in the rainy season will understand how important a good road system is for the opening up of a country. Even the open orchard country of the hinterland of Nigeria

is in many places, to this day, as impenetrable as the British Isles were before the Romans built their roads. Altogether, there are now 80,000 miles of trunk and secondary roads in British Tropical Africa—a fine achievement in half a century.

In East Africa, there is now the fine port of Kilindini near Mombasa, where none existed in 1900. The Gold Coast has the modern port of Takoradi. In Nigeria, Lagos, Port Harcourt and Burutu have up-to-date port facilities, handling altogether nearly 1,500,000 tons of cargo in a year.

Summary of Achievements

I hope by reciting these facts and figures—which are merely and necessarily brief selections from a whole body of evidence—that I have shown clearly how immense are the strides made since the beginning of this century. In that period there has been a vast growth in the population of British West Africa, which has doubled, or more than doubled ; a growth made possible by the peace and security to which the savagery and tribal warfare of fifty years ago has had to give way.

Before turning to the future, I would like to round off this part of my subject by referring to the extent of European capital investment in British Tropical Africa. Professor Herbert Frankel estimated in 1936 that the total capital invested from abroad in the East and West African colonies amounted to £215 millions. Apart from the German investment in Tanganyika prior to the war of 1914, virtually the whole of this capital was provided by the U.K. Indubitably there must have been substantial external investments since Professor Frankel compiled these figures, and it would probably not be an over-statement to say that the total external capital investment up to date must be in the region of £250 millions. This gives no indication of the probable value of this investment at current prices. To judge by the experience of those who have businesses in Tropical Africa, I think we may safely say that the ' replacement cost ', at current prices, of the United Kingdom investment in British Tropical Africa might well amount to double that figure—that is, to £500 millions.

Tropical Africa has developed only since Europe found a use for tropical products ; but in the last fifty years she has advanced to a degree that could not possibly have been foreseen by the pioneers who gave time, money, and in many cases their lives, to the opening up of these territories.

I want to stress this point as strongly as possible because I believe that we are far too prone to under-estimate our efforts and our achievements and to accept meekly the criticisms of the uninformed. Our critics are rarely constructive and many of them have neither knowledge nor experience of Colonial problems ; and, knowing no better, are apt to measure the social and economic progress of tropical Africa against the standards to which they are accustomed in Western countries. Whilst we have certainly no reasons for complacency, you will, I hope, agree with me that far from having cause for apology, we have every justification for feeling great pride in our achievements.

Future Prospects

I now turn to the main and most difficult part of my subject : the prospects for the future. These can I think be best considered under the headings of : Agriculture, Minerals and Industry.

Agriculture

As regards agricultural production, my general conclusion is that there is a vital need for development of new sources and extension of existing sources of wealth. The Pax Britannica and the spread of health services have resulted in most of these territories in large and constant increases of population which are far out-stripping the development of additional sources of wealth. Failure to increase productivity must result inevitably in the lowering of standards of nutrition, and in the shrinkage of social services, such as health, housing and education, all of which are still at a low level despite the strides made in recent years.

Any substantial decline in commodity prices in world markets—a downward trend is already noticeable—would result almost at once in a heavy reduction in Government revenue. Colonial Governments would in consequence be unable to maintain the social services which are being developed largely with the aid of substantial sums deriving from the inflated revenues of the last few years, supplemented by grants provided under the Colonial Development and Welfare Act.

We are inclined to overlook the fact that when the supply of palm oil and copra from the Far East returns to its pre-war level—as it surely will—the peasant production of oil and oilseeds in West Africa will be exposed to the full force of competition in world markets. Again, in the Gold Coast, in spite of this season's unexpected rise in production, cocoa is earmarked for a speedy decline, owing to the ravages of Swollen Shoot disease.

There is wide misconception regarding the agricultural potentialities of British Tropical Africa. It is little realized that tropical African soils are amongst the poorest in the world. The apparent richness of the soil in the Forest Areas is deceptive : the forest lives for the most part on the products of its own decay ; and when the forest cover is removed, the surface humus is in imminent danger of erosion.

The fact that the soils are of such poor quality and readily erodable does not mean that great development in agricultural production is not possible of achievement.

Throughout these Colonies, with of course, the notable exceptions of the White Highlands of Kenya, certain areas of Tanganyika, and the cocoa areas of West Africa, the majority of the peasant population—which comprises perhaps nine-tenths of the total population—carries on its agricultural pursuits on the basis of subsistence farming, using methods which vary little, if at all, from those in use in Biblical times. In most cases the sole agricultural implement is a hand hoe. Little, if anything, is returned to the soil, and when constantly declining yields demonstrate that the land will no longer give a yield, a system of shifting cultivation is pursued : the worked-out land is left to lie fallow for a period of years, thereby regaining some of its former fertility,

whilst the cultivator moves on to another plot which has in its turn been lying fallow. This was all very well so long as the ratio of land to population was ample, but with the growth in population and the increase in the cultivation of money crops in addition to those grown for subsistence, the continuance of these methods is no longer possible.

The system of land tenure tends further to intensify the difficulty in bringing about rapid changes in agricultural methods. It is impossible for me to go into the detail of the widely varying native laws and customs regulating the rights over land, but as a broad generalization it can be said that there is no private ownership of land in the sense of European freehold ownership. Although an individual may have the use of a particular plot of land—or indeed the right to crop certain individual palm trees in a natural palmery—his rights in the land and what he can do with it are limited by other rights held over the same land by his family, clan or tribe.

Further, throughout British West Africa any alienation of land, even by way of leasehold, for plantation development is taboo. Without questioning the wisdom of this policy, which is based on the threat to tribal life constituted by the introduction of plantation methods, we must appreciate its effect on the production of wealth. For example, the Dutch East Indies which only started palm cultivation in 1919 were producing in 1939, by plantation methods, nearly twice as much exportable palm oil as Nigeria. The production of palm oil from the natural palmeries in Nigeria suffers a triple handicap by comparison with the plantation industry of the East Indies :

1. The low oil content of the Nigerian palm fruit ;
2. The low percentage extraction of oil ; and
3. The low quality of the final product.

So it will be seen that the development of new sources of wealth on the all-important agricultural front in Africa is a problem that is not going to be easy to solve ; but if it is not solved, and solved in good time, the consequence to the world at large will be most serious. To the African people it will be disastrous.

Sir Philip Mitchell, the Governor of Kenya, in his despatch No. 44 of 1946 to the Secretary of State for the Colonies, deals comprehensively with the general aspects of the agrarian situation in that country. He sums up the position very clearly in the following sentence : 'I feel justified in saying now that I believe firmly that research will disclose that primary production by African peasants in the manner in which it has hitherto developed is already on the decline, and that in fact, far from there being any possibility of its substantial increase, populations working under that system are going to find increasing difficulty in supporting themselves even at their present level'. Africa dare not ignore so clear a warning from such an outstanding Colonial administrator.

Some system of collective or co-operative farming will have to be devised so that areas can be created which are sufficiently large to justify the introduction of modern methods of agriculture, and thus bring to an end the utterly wasteful system of shifting cultivation and the destruction of the soil by over-cropping and erosion.

But there are large areas in Tropical Africa which do not suffer from pressure of population and where the potentialities have not yet been touched. The areas in Tanganyika at present under development by the Overseas Food Corporation in their immense East African Groundnut Scheme represent only a fraction of the under-developed lands of the territory we are considering. I believe that despite the many unforeseen difficulties with which the Groundnut Scheme has been faced in its initial stages, it and similar developments in other parts of Africa—for example in the Northern Territories of the Gold Coast and in Northern Nigeria—will not only prove fully justified economically as a means of adding to the wealth of Africa and the world, but, equally important, as the means of spreading the knowledge of how to use modern agricultural tools and how to apply up-to-date agricultural methods.

One of Africa's most urgent needs, and a prerequisite of any large scale creation of wealth is, clearly, the education of the African peasantry in the ways by which they can improve their agriculture. I firmly believe that the more practical forms of education—agricultural and so on—should take precedence over the ordinary educational syllabus. This would have the immediate effect of bringing about a rise in the standard of living of the African peasant, and adding materially to his social contentment.

Tropical African agriculture has to overcome not only the difficulties inherent in undue conservatism and ignorance among the peasantry, but also grave problems arising from pests and disease. A striking and most serious example of this is the present unhappy position of the cocoa farms in the Gold Coast.

At the end of 1947, one-eighth of the cocoa trees in the Gold Coast were estimated to be infected with Swollen Shoot disease. There is no known cure for this ; but if the infected trees are cut out, the disease virus dies with them. The disease is now gaining on the rate of cutting out ; and the rate of its spread appears to be progressive. Unless the Gold Coast farmers give far greater support than they have hitherto given to the efforts of Government to combat the disease, it may well be that the industry will be wiped out within a generation. The effect of the failure of cocoa on the economy of the Gold Coast would be catastrophic, as cocoa constitutes virtually the sole agricultural export of the country.

But over the whole of the agricultural picture there is a ray of hope which, if it develops into actuality, may have a striking effect on the position in the next ten or twenty years. I refer to the recently discovered drug called 'antrycide', which it is claimed cures trypanosomiasis in cattle, the disease which in human beings is known as Sleeping Sickness. It is said that a single injection of this drug will cure the two worst forms of this tsetse fly borne disease and that after simple instruction any African cattle owner will be able to cure his sick beast and safeguard his healthy ones from infection. If these claims, which are based on long term experimental work, prove to be well founded, it will result in the opening up to animal husbandry of immense areas where at present cattle cannot live.

The whole of the Gambia, Gold Coast and Sierra Leone, about four-fifths of Nigeria, and very large areas of East Africa are infested with the tsetse fly and are deadly for cattle.

Apart from the opening up of a very important new source of wealth which could greatly improve the nutritional standards of the people—for animal protein is an outstanding deficiency in diet—the ability to keep cattle in these areas could have most important repercussions on the agricultural economy. It would enable mixed farming, which is at present practised to a small but growing extent in Northern Nigeria, to be extended widely in Tropical Africa.

Mixed farming, correctly applied, enables a farmer to cultivate about twelve acres with an ox-drawn plough, as against three or four acres by a hand hoe, whilst the fertility of the land is maintained by the manure provided by the beasts. In the report of the Agricultural Department of Nigeria for 1932, quoted by Professor Hancock in his 'Survey of Commonwealth Affairs', it is said that 'To the farmer's family, mixed farming means rapid elevation to a totally different level of prosperity and well-being'. It is satisfactory to be able to leave a rather gloomy survey of the agricultural front on this more hopeful note.

Minerals

Up to now, I have talked about the future of the *surface* riches of the land : the agricultural wealth of Tropical Africa. Let us now consider the riches buried below the surface. Agricultural wealth has from time immemorial been developed to a limited extent by the African peasant : he has, with little or no capital, been able to wrest from the land at least a bare living for himself. But mineral riches are in quite a different category. Except for the primitive form of gold mining practised in West Africa thousands of years ago, if Herodotus is to be believed, mining activities have not been able to progress without the aid of European capital and technical knowledge. Minerals, of course, are a source of wealth to the African—wage bills for labour are large and Government derives considerable revenues from royalties and taxes. But the fundamental difference remains, British Tropical Africa is primarily agricultural, and direct income from mining activity flows to a small section of the community only.

Although the mineral resources so far discovered in these territories are of substantial importance to their economy, present evidence does not suggest that the further extensive geological surveys which are now taking place are likely to uncover new resources of revolutionary importance.

Let us not finish the discussion of mineral resources on too pessimistic a note. It may, I think, be fairly said that whilst on the mineral front there is no likelihood of rapid strides, and whilst actual prospects are at the moment limited, it is not too much to hope that as a result of the intensive surveys which are being made, at least some substantial new sources of wealth may arise.

Industry

I now come to what is perhaps the most topical part of our subject—the problem of setting up industries in Tropical Africa. I have said earlier that Tropical Africa is primarily agricultural : but this does not dispose of the problem. The United States of America were once primarily agricultural :

now they are the greatest industrial nation in the world. India was—and still is—first and foremost an agricultural country : but many great industries have been developed there—I need instance only one, the Tata Iron and Steel Company.

What then are the prospects for industry—other than mining—in Tropical Africa ? So far, industrial production—by which I mean the processing of raw materials or their conversion into manufactured goods—has made very little progress. The reasons for this would seem to be that manufacturing industries, to be successful, require a combination of all or some of the following features :

(*a*) Ample and cheap sources of power ;

(*b*) Availability of the required raw materials ;

(*c*) Sufficient supply of labour, with the ability to master simple techniques to which it has not previously been accustomed, and ability to reach fairly high standards of efficiency ;

(*d*) A reasonable choice of workers, with fair standards both of education and character, capable of acting as charge hands, foremen and overseers ;

(*e*) Conveniently situated markets.

I omit reference to management grades of staff as these could be provided at the outset by expatriate staff.

To what extent do these resources exist in Tropical Africa, and can they be readily developed ? Coal supplies are strictly limited and with two notable exceptions (the Volta and the Owen Falls schemes) the prospects of cheap water power are not good. Labour is relatively inefficient, and, no doubt owing partly to poor nutrition, its output is very low compared with that of unskilled labour in Western countries. The supply of workers possessing foreman and overseer qualities is virtually non-existent. Raw material is limited to the small group of minerals and to the agricultural and sylvan products to which reference has been made. This picture does not suggest that large or rapid developments can be looked for in this field. But this certainly does not mean that nothing can be done to introduce gradually a number of smaller manufacturing industries in those fields where African conditions do not weigh too heavily against the chances of success.

The first example that springs to mind is the Timber Industry. This, in the classification I have been using, is a hybrid. It is like mining, extractive —but it does not exhaust the natural resources. It is, in its later stages, a precision industry, using the most modern equipment for its sawmills and plywood factories.

A good deal still remains to be done to bring the utilization of the timber resources of Tropical Africa to a stage of full development. That the Nigerian resources are being fully worked is due to the fact that most of the high forest outside the reserved areas has been destroyed to create farming land ; but in the Gold Coast there are magnificent forests from which rapidly increasing quantities of hardwoods are being extracted. The potentialities are fully

realized and a great deal of capital is at present being sunk in creating new facilities both for evacuation to railhead and for the erection of modern conversion plants.

East African sources are not nearly so prolific, but there is much timber in Southern Tanganyika, and the new railway at present under construction in that area for the development of the Groundnut Scheme should enable a lot of timber to be made available both for internal consumption and the export markets.

The European in the tropics—and here I refer particularly to West Africa—has been aptly described as ' the most expensive of God's creatures '. This is due to a variety of unavoidable causes into which we need not enter here ; yet the fact remains that the all-in cost of maintaining the most junior European employee in West Africa today is not far short of £1,250 per annum. At this point, I would like to pause to correct a common misapprehension. It is often hinted that we tend to use our Colonies solely to provide posts for our likely young men. The reverse is the case, at least in private enterprise. To employ a European in Africa is a very costly business, as I have already indicated : and commercial firms do not incur such expense unless they have to. As soon as Africans reach the required level of technical and managerial ability, they are given the more responsible and lucrative posts.

It is obvious therefore that to support the heavy costs for imported overseers and technicians, an industry must be of a nature in which the ratio of unskilled labour to skilled and supervisory staff is very high, or where some other compensatory advantages exist.

A good example of the latter is the recent development in Nigeria of a large modern plywood mill. The conversion of logs into plywood results in the production of about fifty per cent. of waste material, and in consequence the heavy freight charges which would otherwise be incurred on the export of logs for conversion overseas are halved. Furthermore, unsuitable material can be isolated before the process of manufacture has gone far, and the whole of the freight on this saved. Above all, the steam and power needed for the production processes can be raised entirely from the waste arising in manufacture.

Similar considerations apply to sawmilling, and the possibilities of other forms of conversion of hardwood logs, including the production of cellulose from species not suited to more refined processing, certainly justify intensive study.

The manufacture of soap in Nigeria takes care of most of that colony's requirements, and this industry is capable of extension in other territories which produce suitable raw materials.

There are also large modern tobacco factories in Nigeria and Uganda, and breweries both in East and West Africa.

Kenya, with its constantly growing settled population of white people has not the same problems as the rest of the tropical African colonies, and there a number of small industries have been established under war conditions. It remains to be seen whether their degree of efficiency will enable them to face the full force of outside competition.

The textile industry also offers certain possibilities. Cotton is produced in quantity both in East and West Africa, more than sufficient to support a large textile production ; but power consumption is high, and it would be necessary to maintain for many years, at the very high costs to which I have referred, an excessive number of supervisory and technical personnel. It will be a long time before Africans reach a standard anywhere near that of Lancashire. There may even be physical defects to overcome. It has been found in Egypt, for example, that Egyptian spinning operatives are far below the standard of Lancashire not because of lower intelligence or manipulative skill—but because a large proportion suffer from defective eyesight.

In East Africa the development of the great hydro-electric scheme at Owen Falls, near Jinja in Uganda, should in due course make very cheap power available in close proximity to the cotton growing areas. Of Jinja, Mr. Winston Churchill wrote as long ago as 1908, using that picturesque turn of phrase we have since come to associate with him :

' Jinja is destined to become a very important place in the future economy of central Africa .....It is possible that nowhere else in the world could so enormous a mass of water be held up by so little masonry '.

Large scale sources of power are rare, however ; and in most cases I feel that the best policy would be to start a new industry on the basis of the smallest possible economic unit, thereby gradually developing skills and techniques, and enabling the more apt of the unskilled workers to develop the qualities necessary for promotion to charge hands.

I know of no group of industries which, if they can be established locally, could contribute as much to the economic life of Africa as the production of inexpensive and reasonably durable building materials. The cost of imported cement, and of asbestos and iron roofing materials is an immense barrier to the fulfilment of Africa's greatest social need—decent and cheap housing. Such industries would have to be localized so as to avoid high internal transport costs, and I have no doubt that intensive research on a large scale would be justified. Failing a solution, any rapid advance in this important social field must be indefinitely delayed.

But apart from industrial production utilizing modern plants and techniques, there are substantial possibilities of developing further peasant industries such as spinning and handloom weaving. Much work is being done in this field, and in Nigeria there is already an important handloom industry.

So it would seem that new sources of wealth from industrial production can only develop slowly, and the pace of progress must depend, more than anything else, on the speed with which practical education advances ; and advance it must, if we are to provide skilled operatives of the quality requisite to keep the wheels of modern machinery turning. Indeed I would go so far as to suggest that basically this is the overriding problem of Africa.

The provision of capital is not the outstanding difficulty. Despite the stringency of our own economic situation, I have little doubt that capital would be forthcoming to develop such undertakings in Africa as offer a reasonable prospect of yielding a fair return. Let us remember that an undertaking

which will not measure up to this standard is not creating additional wealth. I believe that private enterprise, despite the immense burdens of taxation, can still play a large part in the provision of capital for these developments, and the Colonial Development Corporation, with its many millions of public money will be constantly seeking opportunities for investment where there are prospects of success.

We frequently read that 'Africa is caught in a vicious circle' of cause and effect, from which she cannot escape unaided. The argument is made in these four stages :

1. African communities are poor.
2. Therefore they are badly fed, liable to disease, and ignorant.
3. Therefore they produce little wealth.
4. Therefore they are poor.

I prefer to look at it this way : Each of these statements is a different way of saying the same thing. Africans suffer from poverty : poverty of wealth, body and mind. The three are inseperable. We may come to their assistance by importing our capital, our medical services, or our education. Whichever we bring will improve the lot of the African : it will be something we give or lend to the African. Without our aid, African institutions and peoples are likely to crystallise into what Toynbee describes as a state of arrested development. We have it in our power—given the goodwill of the African—to infuse new life into the march of civilization in Africa.

There are two essentials of which we must not lose sight. First, the pace must not be forced, either from within or without. Second, strenuous attempts must be made to ensure that the educated Africans—and they are rapidly growing in number—have some appreciation of the need for great efforts to be made by the African peoples themselves. The understanding of simple economics is woefully lacking in even the best educated of them, and there is at the present time far too great a tendency to regard grants-in-aid as payments belonging to them as of right—and to demand them in ever-increasing measure. Were the educated classes to devote a tithe of the efforts which they at present devote to political agitation to the bettering of the social and economic condition of their countries, the outlook would be more cheerful than it appears at present. The point I am trying to make is well illustrated when one considers the avocations of the substantial number of West Africans with professional qualifications.

The latest figures I have been able to obtain of West African students studying in the United Kingdom show that of private students, 182 are studying Law, 170 Medicine, and 37 Engineering ; whilst of Government Scholarship students, 9 are studying Law, 32 Medicine and 45 Engineering.

The difference between the pattern of these figures for private students on the one hand and government scholarship students on the other is most revealing. Amongst the private students the number studying law exceeds the number studying medicine and is nearly five times the number studying engineering, whilst amongst the scholarship students, the number studying

engineering exceeds the number studying medicine, and is five times the number of potential lawyers. The Governments of British West Africa evidently have a much better idea of what is good for Africa than have the Africans themselves.

Unless Africans make a determined effort to make their own contribution to the development of their own country, nothing we can do in the long run will be of much effect. If, as at present, the Africans continue to hold the view that self-government and political independence, can be achieved ahead of economic independence, then the outlook is indeed gloomy. In the absence of that social and economic advancement so vital to the African peoples, it would not be long before their state would be little, if any, better than that of the Kingdom of Ethiopia.

On reviewing the facts, I can only reach the conclusion that there has been a great deal of wishful thinking on the part of the many writers and speakers who have, since the war, created an impression that Tropical Africa is an El Dorado of wealth sorely neglected in the past and capable of being developed rapidly on a grand scale. I take a far more sober view of the position. Provided that all the efforts at present centered on aiding the progress of these areas are able to fructify (and they can only do so against an orderly and sound political background) then I believe that we are justified in expecting a gradual increase in the production of wealth and a concurrent and perhaps co-equal improvement in social conditions. To look for more would in my opinion be to give way to easy and unjustifiable optimism.

GROUP FARMING

THE search for an ideal organisation of tropical farmers continues. In the last century the advocates of the estate organisation outnumbered all others; at the beginning of this century advocates of individual peasant farming became numerous. Today a number of authorities are advocating a half-way house between the two, some form of group farming of semi-independent peasants. The theory of group farming appears superficially attractive and some assessment of its potentialities seems justified.

Group farming is recommended both on social and economic grounds, sometimes rather on the supposition that two recommendations in any case are better than one. It should be emphasised at the outset that social problems in most tropical countries today and for some time to come are in fact economic ones. There can be no real question of whether it is socially desirable for an individual to be a wage earner or an independent proprietor if one condition may raise his productivity and earnings while the other is likely to leave him at his present low level. It is mere sentiment to call any condition a " way of life " when that way provides total earnings of only a few dollars per year. Independence in abject poverty is no social goal whatever.

In any case it would seem that the opprobrium attached to wage paid labour in the tropics is rather exaggerated. In other parts of the world more than half the population is supported and comfortably served by wage work ; the wage worker is often far more independent than the proprietor tied by the responsibilities of business; it is quite false to assume that wages

of the tropical estate labourer must remain at low levels. Heavy manual work in the fields cannot pay reasonable wages in competition with overseas production carried on with machinery; but the fault has not been so much in the estate organisation, but the previous reliance on manual instead of mechanical power. There are a few examples today, steadily increasing year by year, where mechanical power is extensively employed and labourers' wages correspondingly increasing.

The swing of opinion away from the individual peasant farmer is attributable to the increased mechanisation of tropical agriculture and the lack of success that has attended efforts to settle peasants on the land. This lack of success of peasant agriculture is perhaps more apparent than true, because the obvious examples are settlements sponsored by Governments. These conscious efforts of settlements were from their very nature hot-house developments ahead of the natural trend; they were, therefore, less likely to succeed than the very considerable natural development which has been going on since the beginning of the century. The natural development of peasant farming of sugar-cane, cocoa, rubber, and other crops are of immeasurably more importance to tropical agriculture than the few not very successful settlements sponsored by Government.

The increased mechanisation of many branches of tropical agriculture certainly puts the small individual peasant at a disadvantage. His small area of land is by itself unsuitable for mechanical tillage even if equipment is available on hire for the purpose. It must, however, be remembered that mechanisation is only one of the important technical improvements which are being developed today. Another improvement of equal importance is the improved planting material of many crops. Better plants will not only give greater production under average conditions but a greater response to special treatment. These special treatments are becoming ever more varied as knowledge of the use of manures, insecticides and fungicides increases. In fact, improvements of this kind may actually favour the peasant who, from his small scale of operation, can give more attention to individual plants and fields than the large estate where mass production is the essence of operation. New techniques, in fact, do not at present seem to favour either large or small scale production particularly; some of them will be of greatest benefit to the large unit, others, if fully used, to the small unit.

The essence of group farming, whatever the degree of co-operation among individuals, is to obtain the advantages of both large and small scale production : for the unit as a whole to enjoy the advantages of mechanisation; for co-operating peasants to exploit the advantages of close, personal supervision of small areas and numbers. Such conditions, if they were in fact attained, would be overwhelming and estates and peasants alike would have been superseded by group farming long ago. In point of fact group farming is until today almost unknown in the tropics and is a rarity in any country. There must be some defects which do not permit the realisation of the apparent economic advantages. These defects arise from the fact that individual units are essentially not compatible with a united whole. Although the advantages of both may be realised, their conflict often results in neither of them being achieved. Each of the group farmers must sacrifice some of his independence if he is to derive the benefit of group operation: he can only

grow certain crops on certain areas and must adjust his stocking for those crops ; he must manage the crops to suit the programme of the group and must make his livestock management subservient to crop management.

In the same way the advantages of large scale operation may be impeded or actually sacrificed to the independence of the individuals. The success of large scale operation does not depend entirely on the possession of specialised equipment, but also on good organisation and strong management to use it effectively. For instance, mechanical cultivation can be most costly if through lack of organisation expensive equipment is not utilised to its full capacity. It is difficult to see how a group authority could maintain the requisite firm management without becoming a dictator, however benevolent, over the individuals. They would have to sacrifice their independence and at best become sleeping partners in the undertaking; at worst, labourers with not even regular weekly wages. The problem of management has been one of the greatest defects of any co-operative effort. A manager elected from or appointed by the members rarely proves to be as effective in controlling the members and their business as a company director in managing his shareholders' affairs. Agricultural marketing, where the possible economy is often large, has proved weakly enough; agricultural production seems an even less promising field for co-operative effort.

Is there, therefore, any future for group farming? As with any other organisations there are conditions in the infinite variety of agriculture which favour such an organisation; but group farming, as with any other system, can never be of universal application or an object in itself. The conditions under which group farming should be superior to any other system are those under which certain features of production overwhelmingly favour the large organisation but other features equally overwhelmingly favour small units. The more distinct these two conditions can be in the cycle of production the greater advantage group farming has over any other system.

Wherever irrigation, heavy mechanical equipment or other large capital expenditure is required, the large unit will be favoured; wherever light, skilled handwork, close observation and personal attention are required, the small unit will be favoured. A combination of these two conditions can be found in irrigated production of a crop such as cotton and the Gezira plantations are practical evidence of this combination. Other tricky crops where personal attention is rewarded by high returns, such as tobacco, might, if requiring irrigation or other heavy group capital outlay, also form a sound basis for group farming. Similarly, if in any area soil conservation measures entailing heavy capital and upkeep expenditure resulted in increased production and responsiveness of crops, crops which were particularly suitable to small scale production could be most economically produced on group holdings.

The greatest opportunity for group farming is possibly mixed farming. The production of many crops is more suited to large scale operation than small, but the good management of, and production from, livestock is always more difficult to achieve on a large scale with paid labour than on a small holding of an enlightened peasant. If future research proves that any soils or crops in the tropics do respond markedly to the application of organic

manure, the organisation most suitable for producing that manure may be a group farm. The livestock would be owned and managed by the small individual farmers while the cultivation of crops would be undertaken largely on a group scale.

This brief discussion of group farming assumes that a peasant is always in a position to exploit any advantages there may be in a particular system of small scale farming; that he always has the required capital, education and experience to apply detailed management. He rarely has. In fact the most serious practical difficulty of peasant farming is to convince farmers that it is in their own interest to pursue a system that conserves fertility and farming equipment; often enough there are neither of these assets on the farm to conserve.

A form of group farming might be made to serve this essential educational and financial service. A group authority by lending the required capital to individual farmers could compel them to farm on an approved system. Such a group would no doubt have to be financed originally from public funds. But as increased earnings convinced the peasants of the cash value of good farming, surplus funds could be invested in a group Bank which would gradually supersede the State's interest.

A. L. JOLLY.

PLANNED GROUP FARMING IN NYANZA PROVINCE, KENYA *

THE urgency of the need for a radical change in land utilization to save the soil and to improve or even to maintain the returns from African peasant cultivation is now generally appreciated.

2. The possible means of attaining this change are the development of mixed farming small holdings, large farms with employed labour, collective farms, or through some form of co-operative farming under acceptable local land authorities.

3. It is felt that the change cannot be attained by the development of individual mixed farming small holdings with all the difficulties of economics and efficient usage, and existing systems of land tenure—with fragmentation. Such holdings have been developed for experimental and demonstration purposes on the Agricultural Department's Farm at Bukura.

The economic shortcomings are apparent and there has been no real spread of practices thence to the neighbouring African lands.

4. The evolution of large farms with employed labour would in general be too gradual a process and open to doubt ethically, particularly as sufficient industrial development to absorb the surplus population is most unlikely.

The possibility of collective farming has been mooted but seems to be too dependent on drastic coercion of the sluggard to be considered. Effective management is unlikely to be forthcoming, and from many points of view, the idea would be abhorrent to the African.

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5. Co-operative effort would appear to be the right approach, and the Agricultural Officers in Kenya passed the following resolution at a Conference in 1947 : —

> " The policy of the Department for the native lands shall in general be based on encouraging co-operative effort and organisation rather than individual holdings. It is considered that only by co-operative action can the land be properly utilized, and the living standard of the people and the productivity of the land be raised, and preserved. While this involves a change from the modern trend towards individualism it is in accord with former indigenous methods of land usage and social custom ".

6. With heavy intensities of rainfall drainage type terraces are generally required in Nyanza, and it is necessary for the land to be treated in drainage units for conservation and proper utilization.

7. Lack of planning can be seen everywhere in the siting of villages, the haphazard planting of fruit and timber trees, in the use of steep land for annual and flat land for perennial crops. Difficulties of access to grass leys prevented by neighbours' crops, in contour ploughing, and in siting drainage ways and the like are concomitant with individualism, fragmentation and lack of planning. To overcome these difficulties a method termed ' Planned Group Farming ' was advocated.

8. Basically this entails initial planning by the members of a group, and similar use of contour strips by neighbours, as the boundaries between holdings normally run from the top to the bottom of the slopes.

The use of each strip from drainage way to drainage way would be decided, based primarily on soil and topography. A strip would be chosen for housing, others, depending on the slope, for bananas, fuel or timber plantations, or permanent grazing, and the flatter land for alternate husbandry, arable and grass leys, in accordance with an agreed rotation.

There would be no interference with the individual's tenure of his holding, but he would have to use each contour strip within that holding in conformity with the edicts of the group or its committee.

9. Permanent hedges or fences would be allowed only round the perimeter of the group farm and on the contour, and in cases where permanent pasture is necessary for the rotational grazing of such pasture. Normally where soil, climate, topography permit, alternate husbandry should be adopted, though this may take time. Any fencing between holdings for grazing must be removable, so that, for the arable courses of the rotation, the implements can traverse all holdings on the contour.

10. With individuals owning scattered holdings, it may be necessary for some to be members, at any rate initially, of more than one group and there is nothing to preclude this, though consolidation by exchange would be encouraged and expected.

11. Mutual trust is essential between members of a group, who would normally be relatives, and there is no limit either way to the number of members or to the size of a group farm, which would be bounded on each side by drainage ways. Natural drainage ways are preferable, but grassed channels can be made where necessary. As group farms develop they may combine with others to form Unions for marketing produce, acquiring dips, dams or other improved water supplies and farm machinery.

12. The system permits the use of mechanical equipment and economics in oxen and implements, and can progress through Co-operative Better Farming Societies, controlling their members, obtaining loans, acquiring their own implements and marketing their own produce. It provides scope for specialization, since the groups will, as they develop, require stockmen, dairy experts, marketing clerks and perhaps tractor drivers and the like. It is hoped that the groups will select youngsters for training on these lines, who will return and be their specialists. It is also hoped that membership of a group will provide the necessary insurance without which salaried Africans cannot be expected to leave the land. Above all Land Authorities in the form of the Group Farm Committees would develop, and some form of such authority is deemed essential, if any real and lasting progress is to be made.

13. The adoption of dipping and limitation to carrying capacity for the improvement of livestock is difficult, while stock have free range over all fallow land, and are regarded more as a social than as an economic asset. Group farms and their committees should assist with this development, and with improvement through the group ownership of improved bulls and, as they develop, through having their stock specialists. In certain overpopulated areas group farming with mechanization should assist by allowing the use of all the limited grazing for the production of milk.

14. Safeguards will be needed to ensure compliance with group edicts, and it is thought that this can best be attained through bye-laws after registration of the groups, as Co-operative Better Farming Societies. These would not, however, cover withdrawal from a Group by a member or his successor, after due notice, and rules under the African District Councils' Ordinance are envisaged to ensure that all users of land in a group farm follow the farming practices, and use of contour strips as decreed by the majority of the members, or the committee on their behalf.

15. Such a change in farming trends is not one that can be imposed by a Government order alone, and it is clearly understood that we must have the African with us, and make him realise that the group is his, and that he must produce his ideas and views, when he seeks our guidance. Group farming is really only a modernized version of much of the old indigenous system of land control and usage.

It is felt that it is a method of attaining good farming with its proper balance between crops and stock, and by which, where topography permits, the use of mechanical equipment as an aid to hand labour is feasible, and which should be acceptable to the African.

16. On 6th February, 1948, the Provincial Team agreed that this system should be encouraged, and that assistance for Group farms was a very suitable purpose for the expenditure of monies from Agricultural Betterment Funds. These funds, held by Native Councils, have accrued from the collection of a cess on maize sales for agricultural betterment, originally on the suggestion of people of the Kitosh tribe in the North Nyanza district. District Teams and Local Native Councils also supported the proposals. Money has been provided this year for Mechanical Units and for assistance for better farming. This assistance is not of course confined to Group Farmers.

17. Since the proposal was approved Africans have shown great interest. Already in the Central Nyanza district the Luo, a Nilotic tribe, have formed 24 groups with 540 members covering some 7,805 acres. No mechanical assistance has yet been possible, but most of the groups have made a good start with preparing drainage ways and terraces, applying manure, planting grass and closing grazing areas for recovery. The first group to be formed, that at Nyahera, which has 77 members and 960 acres of land, has made most progress. They have stated that they realise that not more than half of the land should be cultivated at any one time, and that they are willing to sign an agreed set of rules, and to pledge unlimted security in the event of their group receiving a loan for development. Land exchanges are taking place and all members are making manure. One, who has no stock, obtains manure from a neighbour in return for all his stover and assistance in making. Two strips have been planted with grass for leys this season.

18. In some areas interest is shown in the possibilities of group farming for rice growing, and neighbours of groups take an interest in their work and discussions and are copying them in some ways, notably in applying manure to their fields.

19. In North Nyanza a start has been made with developing a group farm for trial and demonstration at the Agricultural Department Station at Bukura, and the African Land Utilization and Settlement Board has supported the proposal, that Government should provide funds for the development of a union of three groups at that station. This will provide facilities for investigating the agronomic, social and economic aspects of group farming, for testing mechanical equipment and for training specialists sent there for courses by the varying groups.

20. Several groups are already developing in the vicinity, and it is hoped that the system will radiate out from the station with the assistance of mechanical equipment based on it. Several other groups are developing elsewhere amongst the Bantu in this district.

21. In South Nyanza a number of groups have been formed in the lake shore Lue locations, some of which will use land at present undeveloped. In the Kisii, Bantu, highlands one group is starting, and the Local Native Council and a Location Advisory Council have recommended that an area of 250 acres should be set apart for ten years for trial and demonstration of group farming.

22. In the Kericho district the Kipsigis, Nilohamitics, who until recently were pastoralists, but are now over-cultivating their land for maize production, are showing great interest in the proposals. Their Local Native Council has provided two mechanical units, each with one Fordson and one Ferguson tractor with implements, fencing, and full assistance for ten group farms as a trial. Four of these group farms totalling 1,180 acres with 75 members have now been formed. Perimeter fencing has been completed, graded strips have been pegged and left under grass for terracing later, and some 350 acres have been mechanically ploughed and cultivated. Rotations and strip usage have been agreed, and the requisite maize strips will now be undersown for grass leys. Cattle dips will follow, when the groups develop and show that they can control numbers and grazing for cattle improvement. It is interesting to record that one group has asked for a rain and piped water supply, for which it will pay.

23. In Kericho ownership, or right of user, of particular areas of land has not developed to the same extent, as in the other districts, and one of the first functions of the group, when formed, is to apportion land to its members. This makes land utilization more simple, but may give rise to trouble within the group in the early stages. It does, however, test their mutual trust before development starts.

24. The group farms in this district are planned with seven main contour strips, one for the homesteads, three under grass and three under the plough. Each year one crop strip will be undersown to grass and one grass strip broken for cultivation. Each family has its own holding which extends through all seven strips, and for the present each group has about one-fifth of the total area under permanent grass divided into five paddocks for rotational grazing. The grass leys are regarded as private grazing on his own section of the strip for each member. Land unsuitable for cultivation or permanent grazing will be planted with trees. The management of each farm is vested in a committee consisting of a Chairman, a Treasurer, a Secretary and two members.

25. Numerous applications have been received from others interested in all four districts, and it is apparent that planned group farming is arousing considerable interest in this province. There is certainly no doubt that it has already done much good in getting the African to consider and discuss his agricultural problems, and invite the staff of the department to visit his land and advise. Visitors from other provinces have also shown interest, both in Nyanza and at the Nakuru Show in 1948, when a model was displayed and explained. The social aspects and economics of the system need study and the difficulties, in particular the rampant individualism, that has developed in recent years, are appreciated, but it would appear that by virtue of its elasticity and capacity for gradual development and guidance, this system has great possibilities.

INDUSTRIAL DEVELOPMENT IN THE CARIBBEAN*

Vol. I, Nos. 1 *&* 2 *; Caribbean Economic Review, Dec.,* 1949, *by W. Arthur Lewis. Industrial Development in Puerto Rico*

Vol. II, No. 1*; Caribbean Economic Review, May,* 1950, *by W. Arthur Lewis. The Industrialisation of the British West Indies.*

To the agricultural economist working in the West Indies Professor Lewis' two articles are a breath of fresh, bracing air. He has analysed the progress of industrialisation in Puerto Rico and from the experience there formulated most valuable and practical proposals for choosing and developing industries in the British West Indies. Successful industrialisation would enrich the peoples of the West Indies, both farmer and factory worker alike.

The agricultural economist *must* preach increased efficiency : the more productive use of land, labour, capital and enterprise. Without increased efficiency the earnings of all four partners and particularly the lion's share

* A paper-bound reprint of these two articles is issued by the Caribbean Commission, Kent House, Port-of-Spain, Trinidad, B.W.I.

that goes to labour will remain at a low level ; indeed the present level cannot be maintained if the population increase outstrips increases in efficiency. It is sound to preach these truths and it is easy to show that a man with a tractor or a superior cacao tree can produce more and consume more from a day's work than without. But there are obvious objections which cannot always be satisfactorily answered. The commonest question is what will become of the factors rendered surplus by the more efficient use of some of them. What is to become of the four men who are displaced by the five-fold increase in the efficiency of the fifth ? The conventional answer is of course that higher productivity and earnings generate more employment by providing an outlet for new production from the others. This proposition is undoubtedly true but the productivity of the four displaced persons will be very low if they are confined to agricultural occupations because the one productive individual will spend very little of his extra earnings on food and much on the produce of urban industry. There is some scope for employment of redundant labour in local urban services such as building, transport and entertainment demanded by the higher wage section, but it is likely that a large proportion of the higher earnings and the incentive to secure them will be for light varied manufactures —typical import commodities. An increased demand for imported manufactures will not, however, necessarily increase the demand for tropical agricultural produce to an equal extent ; the higher earnings in overseas exporting countries will stimulate demand for industrial, rather than agricultural products. There is considerable risk, therefore, that increased efficiency in West Indian agriculture will result in the population as a whole being somewhat better off but poverty in some sections to be more acute.

Even on this reasoning the improvement of agricultural efficiency must be right. If it does result in a section of well paid labourers and another section of un-or under-employed, the condition must be attributable to over population and the absence of economic opportunities, and not to any evil of efficiency itself. It is no solution to such conditions to advocate inefficient agriculture which can only result in a working population at a uniformly low and gradually decreasing standard of living. If there really are no opportunities, emigration is the only answer ; political energy and economic resources should be concentrated on making emigration feasible.

But are there no economic possibilities in the West Indies ? Local opinion and long past experience would suggest that they are at best very limited, but as Professor Lewis so rightly says this opinion and experience is typical of agricultural communities and not proof that the development of the right kind of industrial production is impossible. In agricultural countries the business community is concerned more with commerce and the provision of services than industrial production. They are liable to mis-estimate conditions and requirements for success. The commercial businessman is probably no better fitted for industrial production than the farmer himself who has proverbially no knowledge of, nor liking for factories. The experience of industrialisation so far gained by Puerto Rico should go a great way to preventing the more costly mistakes of industrialisation. It appears that in the comparatively brief period since the war the whole concept of industrialisation in that territory has changed and the country is now steadily progressing with a sound type of development. The most refreshing feature

of these articles to the layman is how easy it is to over-weigh unimportant conditions and requirements for industrialisation and how equally easy it is to ignore others which may in practice be decisive.

Probably the most obvious condition to favour the development of a local industry and one which can consequently be easily exaggerated is the presence of raw materials locally. When raw materials are bulky, or lose considerable weight in manufacture, their presence locally does provide natural protection for a local industry using them. When they do not have these properties there is no particular advantage in founding industries on them and there is sometimes an actual disadvantage. Many small handicraft industries using local raw materials have from time to time sprung up but have not survived very long ; the reason for their short life is often that accessible supplies of raw materials in these small islands are soon exhausted and are in fact inadequate for a permanent, expanding industry.

Another fallacy revealed by the Puerto Rican experience is the desirability of basing an industry on local demand. The population of the West Indies, depending for centuries on international trade, take for granted the wide variety of imported goods and do not realise the relatively small quantities of each type and grade consumed. A factory must concentrate on producing simple, uniform products. Its economic output is usually in excess of local demand for the particular kind and quality of article it produces.

One of the less obvious requirements of a projected industry that is proving to be a fundamental factor in its success is the amount of capital required per worker employed. The scarcity of capital and the abundance of labour in the Caribbean make industries with high capital requirements unsuitable. For instance the five fairly heavy industries originally established in Puerto Rico required capitalisation at the rate of about $11,000 per person employed ; the lightest of them, the shoe factory, required only $2,000 per person employed, which is a normal rate of investment in many light industries. On a West Indian scale the 165,000 persons that Professor Lewis estimates will require employment in basic industries during the next ten years will require equipment to the value of $330 million or $1,815 million according to the industries selected. To put this point in another way, unless the labour content in the final product is high and the capital content low, the fundamental advantage of low wages will not be sufficiently exploited to attract new industries and the required capital.

The second less obvious requirement for industry is a good marketing organisation. The output of almost any factory will soon overflow the local demand and overseas outlets must be developed. This requirement is probably an underlying reason why so few industries have developed in the past, not, as is often locally supposed, because overseas producers will not allow local industry to survive ; overseas producers have already built up a marketing organisation superior to anything a new industry can create and they can with no difficulty retain the trade against infant competitors. One of the most valuable suggestions is the overwhelming need to induce established manufacturers who have the required marketing organisation to set up branch factories in the Caribbean. Any manufacturer is cautious about

moving to a new agricultural country even when wage rates are one-half or one-quarter what he pays in his own factory. There is, therefore, everything to be said for giving prospective manufacturers every reasonable inducement to establish branches. The inducements which have proved most powerful in Puerto Rico and the organisation required to make them effective are fully described in the articles.

From the agricultural point of view the prospect of sound, competitive industries in the Caribbean is most refreshing. The whole economy and the agricultural industry in particular is hampered by a deplorable surplus of population in relation to the employment possibilities. There is little inducement for employers to buy expensive machinery or to consider other ways of making labour more productive when there are plenty of people who from poverty are willing to work at low wages with a cutlass or a hoe. If industrial development can productively occupy this surplus there would be real pressure on agriculture to make better use of man power and in that way increase the output and productivity of agricultural labour—A.L.J.

THE GROUNDNUT AFFAIR

By Alan Wood, (*The Bodley Head. Pp.* 265 *and* 15 *photographs. Price:* 12*s.* 6*d.*)

In the first World War Tanganyika was the scene of a campaign which cost 30,000 casualties and £72,000,000. So far the "Groundnut affair" has cost less and has achieved at least something and it is on this note that Mr. Wood has written his clear and vital account of the Tanganyikan experiment.

In one of his war diaries Mr. Strachey, the Minister of Food who caused the experiment to be begun, wrote :

> "Thus far it has been possible to produce these major collective efforts for the purposes of war alone. What could not be done if an expedition.....could be fitted out not in order to decide who should.....develop Africa but in order actually to develop Africa."

Such a vision might inspire an agricultural crusade and Mr. Wood convinces one that, despite the inevitable camp followers, here in Tanganyika was such an expedition led by men who saw the vision (albeit less clearly when the Kongwa dust clouds began to rise) and pledged themselves to it.

Alas, the missionary spirit is not enough ; may it not sometimes even be a handicap. From the inception of this Groundnut scheme the chief actors in it moved with the spasmodic jerks of puppets with a blind man holding the strings or perhaps a better simile would be an amateur company attempting the performance of a play far out of their class with an embarassed world as their audience.

Mistake after colossal mistake crushed any hopes of a successful outcome at least to the Kongwa scheme, yet Mr. Wood tells the story objectively and one finishes the book with a surprising resurge of optimism and a feeling that after all out of the ashes of the Kongwa hopes further successful ventures may yet spring. Perhaps the author's informants are to blame for his references

to Tanganyika Government officials. One recalls the blaming of civilian officials for the military fiasco in Malaya in 1942.

One of the most significant comments on the scheme is not made directly by Mr. Wood but is contained in the photograph facing page 80 bearing the title " Windrows which guard against erosion ". Those who know Africa will see from this photograph that Nature still has another trump card to play. The distance between wind-rows would seem not less than two hundred yards. Elsewhere in East Africa it is thought that strips should not exceed thirty yards in width even on level ground. Can it be that " Government officials " were not asked to advise ?

Mr. Wood's book is so excellent that an error of fact becomes the more obvious. On page 21 he describes the Goans as a legacy left in East Africa by the Portuguese. Actually these admirable and industrious people are inhabitants of the Portuguese Colony of Goa and are Portuguese subjects.

G. ap. G.

THE BRITISH CARIBBEAN

(*Articles reprinted from* " THE TIMES ". *Price :* 1*s*. *Printing House Square*, 1950.)

This booklet reprints articles on British Caribbean appearing in *The Times* between April and September, 1950. *The Times* lives up to its traditions of authoritative journalism.

A.L.J.

MECHANISATION AND FARM MACHINERY

SOME RECENT DEVELOPMENTS IN FARM BUILDINGS AND AGRICULTURAL MACHINERY

In the course of his last visit to England, Mr. John E. Mayne (Senior Lecturer in Agriculture—Crop Husbandry and Mechanisation) devoted a large part of his time to visits planned to get the latest available information on recent developments in connection with farm buildings, agricultural mechanisation and farm machinery. This information was needed primarily with reference to the development and equipping of the new Imperial College of Tropical Agriculture farm and to the teaching curriculum. Notwithstanding this intentional bias in his approach, much of the information he obtained is of general interest to all concerned with agriculture in the tropics. From this point of view, extracts from his report are given below.

I. The Agricultural Research Centre of the United States Department of Agriculture, Beltsville, Maryland

The field work of the Division of Farm Machinery is carried out at field stations throughout the United States of America. The field station at Beltsville deals with fertiliser distribution. Other centres deal with : pest and plant disease control machinery ; tillage machinery ; weed control machinery, specialized crop production and harvesting machinery—cotton, groundnuts, tung nuts, sugar beet, potatoes, sugar cane, sweet potatoes.

Prefabricated buildings are being successful in the United States of America. The Great Lakes Steel Company is producing Quanset type buildings. U.S.D.A. provided plans for their agricultural use. Sears-Roebuck, famous for the " package house ", tried to produce a milking bail, but owing to the variety of agricultural requirements this was not successful. Co-operating with local contractors they are putting up prefabricated cowsheds in the Southeast. They cost about $2,850 (U.S.) complete with eight-stand equipment.

Interesting work on various types of *shade for hogs and beef cattle* has been done in California. Papers have been published in *Agricultural Engineering*, December, 1948, June, 1949. The following shades were used :—(*a*) Wooden slat. (*b*) Hay roof. (*c*) Aluminium. (*d*) Galvanised iron. The hay shade cut off 1.7 per cent. more of the solar energy than did the aluminium, 2.3 per cent. more than the iron, and 8 per cent. more than the wooden slats. The hay and aluminium reduced ground radiation by 28 per cent., the iron 27 per cent. and the slats 22 per cent. In tests with animals, those under the the hay and aluminium were happier and gained a little more. Coarse water sprays were used to some extent by the animals during the afternoons, but fine sprays were not appreciated.

Publications were obtained on Insulating and Weatherproofing (U.S.D.A. Misc. Publ. 633), Planning the Bathroom (638), Farmhouse plans for N.E. States,

(658). These were intended as examples and are very good. "Plans of Farm Buildings for Southern States" is a more useful publication (U.S.D.A. Misc. Publ. 360 and 319) for tropical readers.

Low cost crop drying and storage. The emphasis is on versatility. Information was obtained on the drying of corn, grain sorghum, mow hay, rice, engineering aspects of grain storage, wheat storage in experimental bins, and the control of insect pests of stored grain. There is hope of obtaining a satisfactory cheap crop drier by applying the principle of the common ear-corn drier as used in the United States of America to other uses. Consideration must be given to expected crop yields and the throughput of the drier. In the event of high yields ventilated storage may be necessary to allow of stock piling before the drier. Careful estimates of air volume and temperature requirements must be made and tested under local conditions. The object would be to arrive at a cheap, portable oil-burning furnace with fan air delivery which could be used for drying corn, rice, soya beans, soya hay (or whole plants) and, possibly, grass.

Mention was made of the *harvesting of groundnuts* by a technique which provided for the cutting and drying of the vines for stock feed, and later, the digging and drying of the nuts.

II. The National Institute of Agricultural Engineering at Silsoe, Bedfordshire

The N.I.A.E. receives many requests for information or development from overseas with which it cannot deal satisfactorily. Members of the staff had recently visited Africa, North America, Europe and South-East Asia. It was likely that in the future there would be room for a Section dealing with overseas problems.

The importance of research in agricultural mechanization is accepted in the temperate manufacturing countries. Britain is spending on farm machinery research and testing £250,000 per year, or 0.7 per cent. of the value of the equipment in use in the country. Very little research is done on tropical problems. There seems to be a case for the expenditure of some funds on such research in the tropics.

There has been a great increase in the number of requests for N.I.A.E. tests on prototype and production machines. Tests of several machines were seen in progress. A prototype crawler tractor was seen. Note was made of the Fordson-Perkins on Roadless Half-Trucks, a diesel machine almost as powerful as the Caterpillar D4. The British-built Massey-Harris-Perkins was also seen ; apparently it is equivalent in power to the I.H.C. Farmall M.D. machine. Other new tractors include the Nuffield, the Turner and the Marshall-Fowler.

N.I.A.E. record films were seen of many machines in operation. An expensive but very useful tool is the Trackson Traxcavator. This could be used for draining, excavating (silos, &c.,) bulldozing, manure loading. A Toolbar has been produced for the D4 by Levertons ; this increases its versatility greatly, enabling it to assist with the inter-row work between seasons of heavy cultivation. Copies of field reports were obtained on Green Crop Drying and Pea Harvesting techniques.

The planting of elephant grass could be assisted by means of units for attachment to a tractor toolbar made by A. M. Russell Ltd., Gorgie, Edinburgh. These planters are designed primarily for Market gardening.

No immediate answer will be found to the problem of mechanizing the *harvesting of elephant grass.* A special machine could be constructed resembling the Bamford mower but with a cutter bar width of 36 inches, a stronger cutter bar, and an outriding wheel or skid supporting the cutter bar and adjustable for ground clearances from 2 inches to 6 inches. This machine would cut one row at a time. Other possibilities which could only be judged on their merits in actual work are :—(i) the corn binder, (ii) the rowcrop harvester-chaffer.

In farmyard manure handling the two bottlenecks are transportation and spreading, if spreading must be done in furrows. Other processes can be mechanized provided the buildings favour mechanization and the fields are sufficiently roomy to enable the spreader to work. The alternatives of (i) direct spreading, (ii) pen-spreading, (iii) pen-field-heap-spreading, and spreading on ridge or flat must be examined, because different machines suit these techniques. A calculation will also be necessary of the quantity of dung to be shifted each year and the number of days available for this job —in other words, the minimum shifting rate.

Mechanical manure spreaders work most satisfactorily on the flat. The Thwaites is simple and efficient ; it works on small heaps or banks of manure previously dropped in the field. The Galloway is a power-driven, tray spreader which will carry ¾ ton of manure. It can be also used as a trailer, or livestock wagon. The bottle-neck in a F.Y.M. handling team is usually transportation, especially on long hauls. The most efficient use of the Galloway-type spreaders is only achieved by working several of them with a shuttle tractor. If only one spreader is available the F.Y.M. must be carried on trailers and trans-shipped in the field. It might as well, therefore, be thrown on to the ground for the attention of a Thwaites spreader. In the dunging of ridged land hand work seems to be indicated still.

A simple " in-sack " *crop drier* is being developed by the N.I.A.E. which could, with a certain amount of experimentation, be suited to use with the ear-corn type of drier mentioned above (*British Farm Mechanisation*, October, 1949). A mobile oil furnace could be used to ventilate and dry cob corn in a crib, roughage on a tray or mow, and grain in sacks or on a tray.

III. Farm Buildings

Farm buildings were discussed at Beltsville ; at the N.I.A.E. ; the Department of Agriculture for Scotland ; the Ministry of Agriculture and Fisheries ; and with Messrs. Geo. W. King, Ltd., Hitchin, and Salopian Engineers, Ltd.

A Farm Buildings Conference had been held at Norwich at the end of 1948. The importance of site selection and planning was stressed—although these are difficult approaches in Britain where farmsteads are so very solidly established. Traffic circulation was considered with respect both to the farm

buildings and the homestead. The circulation of livestock, feeds, fertilisers and produce (especially milk) should, and can, be planned carefully to economise in labour and to take advantage of features of the site. *The use of gravity as a free source of transportation power was stressed.* The extreme value of standard structural components was admitted both for speed of erection and cheapness over traditional materials. There was also the advantage that additions and/or alterations could be made unit by unit.

The Ministry of Agriculture and Fisheries has developed a standardised form of construction for farm buildings. The method has been applied to cow houses, milking and dairy units, calf pens, piggeries, covered pens, stables, workshops, implement stores, fodder and fertiliser stores, and stationary plant barns. The structural parts are available for immediate delivery. The principle is the use of standard basic frames with local wall fills where necessary.

Framework : 33 feet and 18 feet span trusses with pressed steel and concrete purlins, wind bracing, eaves, beams, and steel rails for the asbestos sheeting roof. Reinforced concrete stanchions are provided as supports for the trusses in units 18 feet 6 inches (12 inches by 8 inches or 9 inches by 7 inches), 14 feet and 10 feet 9 inches (9 inches by 7 inches) spaced at 15 feet centres.

Roofing : Asbestos (e.g. R.P.M. asbestos roofing) with perspex glazing and Salopian ridge ventilation if required.

Floors : Local material or concrete. (Granary and loft floors should carry 2 cwt./sq. foot.

Precast feeding passage (with ramps, if necessary) and feeding trough are obtainable in units. Yokes ties and water troughs of standard pattern can be incorporated.

Tubular steel piping is used for internal divisions.

Sliding doors are recommended as being economical to use and for saving of space.

Costs may be obtained from Messrs, Hughes Construction (Midlands) Ltd., Unitas House, 24 Livery Street, Birmingham, on submission of a general specification of requirements.

Subcontractors include Beatty Bros.; Gascoigne's Ltd. ; I.C.I., Ltd. ; Salopian Engineers, Ltd.

The advisory services in Britain, in considering designs for farm buildings bear in mind the steady advancement of agricultural mechanization and try to allow for the use of machines which are not as yet common, but some day will be so. Examples are :—the construction of pens into which a manure loader can be admitted, gateways and store sheds large enough to take a combine harvester, space in the processing shed for seed grading machinery.

Special mention should be made of the American barn type of steading. Example : Ramp to unloading level for incoming material at first floor level ; drying floors and storage to be at this level ; gravity distribution to processing machinery, mixing and delivery at ground level (fertilisers could be handled in this way as well as feeds).

IV. Machinery Demonstration

An important N.A.A.S. demonstration of rowcrop machinery and techniques was visited at Bury St. Edmunds. All the standard rowcrop equipment was seen at work including the Bean and Wild "Midget" self-propelled tool frames. The latter were interesting, but quite unsuited to Trinidad. A demonstration of several new Ford implements was attended along with a party of leading European farmers. Sweden, Denmark, Holland, France, Eire were represented. An interesting implement on view was the Ford-Ransome's single furrow reversible plough. This plough is the simplest "one-way" plough yet devised for attachment to a tractor power lift, "one-way" ploughing being important in hillside cultivation. A demonstration of Ferguson equipment was seen at Coventry, where an excellent set of implements for attachment to this pleasing tractor was shown.

V. Visits to Manufacturing Plants and Shows

Visits to manufacturing plants were useful as a means of appreciating the problems of production and their bearing on the final cost, and even on the design, of stock machines. Three distinct classes of manufacturer were visited with the object of seeing their approach to the business and their part in the export trade. On the one hand were the "village" works—virtually overgrown smithies and garages. On the other hand were the large mass-production plants of the "colossi". In between were the medium sized firms, old-established, and saddled with outmoded buildings and venerable capital equipment.

An interesting example of the first class was the works of P. J. Edmunds, Agricultural Contractor, Itchen Abbas, Hampshire. The works is modern, well equipped, and employs, probably, about 50 people. It is definitely a successful business, and Mr. Edmunds says that the policy is to do anything and to do it well. If it is impossible to compete with larger firms in production of popular types of equipment, the answer is to offer individual attention to individual requirements. In this way he has built up a satisfied clientele who have appreciated the personal touch. Mr. Edmunds also contracts in quite a large way with both agricultural and earth-moving equipment. This has led to a remunerative speciality in his business, the rebuilding of worn crawler tracks. Mr. Edmunds has developed several useful items. One in particular is of interest, the P. J. ENCLOSURE. This consists of a steel frame of pleasing design, fitted with sliding doors, which is for sale in sections. Various treatments of the "wall" fills make the enclosure suitable for anything from a semi-permanent fruit net to a kennel.

The shining example of the "colossus" is the Banner Lane factory of the Standard Motor Company at Coventry, where tractors are made for Harry Ferguson Limited. Suffice it to say that it is enormous ; and that it is right out in the country with plenty of room for expansion. It is therefore in, some respects, on equal ground with the leading American factories. The plant is very modern and there is no evidence of limitation on account of outmoded equipment. The plant could produce 500 tractors every day. (The machine tools alone are reputed to have cost £4,000,000). It will be appreciated that this degree of mass production can only to be achieved

given nearly complete standardization of the product. This is especially noticeable in the Ferguson Tractor.

The third group of manufacturers is exemplified by E. H. Bentall and Co. Ltd., Maldon, Essex. Working under extreme difficulty in cramped and outmoded buildings these firms have applied modern production methods as far as possible, but are sill limited (in most products) to manufacture in small batches. Extreme delivery delays are liable to occur while orders accumulate, or while earlier batches occupy the floor space. The number and variety of different models of the same machine, which used to be produced by these firms, has been greatly reduced. Cast iron is giving way to weld fabrication with plate and structural steel. The essence of such production seems to be the satisfaction of specific needs. Specific needs are often limited, so sales of any one machine are not large. Efforts are made to fill any opportune demand. Diversity of production pegs prices high. E. H. Bental & Co., Ltd. were making motor engine valves (a long-established trade) and aluminium (electric) chandeliers as well as many farm and plantation machines.

The following Shows were visited :

The Royal Agricultural Society of England
The Royal Highland and Agricultural Society
The Borders Show (Kelso)
The Clackmannan Agricultural Society (Alloa)
The Angus Horse Show (Cupar Angus).

At all of them the machinery sections were very large and important parts of the shows. At the last three, the machinery was displayed by local agencies.

Throughout the shows the underlying theme was that of direct coupling of implement and tractor. The major aim was to improve the versatility of the farm tractor so that it could be drawn into every series of operations on the farm. The point has now been reached with at least two tractors at which farming can literally be done from the well-sprung seat, such a diversity of tools can be attached at a few seconds notice. All the usual farm equipment was on show, and in addition a number of implements designed exclusively for specialized overseas markets.

Three machines for overseas were of particular interest. The Ransomes *Groundnut Harvester* is clearly a "make-shift" in the design sense, but is doubtless an efficient machine. It consists of the Ransomes (stationary). picker mounted on pneumatics and fitted with a pick-up attachment and its own power unit. It is designed for the smaller grower who cannot afford a modified grain combined harvester, and it is rated at 900–1,600 lb. per hour output. It is intended for tractor draught. James A. Cuthbertson, Ltd., displayed startling ingenuity in their *Water Buffalo*, a new semi-amphibian crawler with a pull of 8,500 lb. ($2\frac{1}{2}$ times pull of Fordson) at $1\frac{3}{4}$ m.p.h. in second gear. The tracks are vulcanized rubber, 24 inches wide and free of wearing parts such as hinge pins. The track can flex in any direction. The tractor weighs $5\frac{1}{2}$ tons yet only exerts a ground pressure of 2.3 lb. per sq. inch. Cuthbertson also showed a *sizal inter-row cultivator and banker* which resembled the more common Cuthberston deep drainage plough.

Three new tractors were introduced at the Royal show, the 3-wheel *Power Steer*, the 8 h.p. *Tractivator*, and the *Nuffield Universal*. The *Turner*

Yeoman had been in existence for about a year. Particular attention has been given to hedge cutting, and one-way and disc ploughs. Salopian Engineers Ltd. have entered the disc plough market. The Reekie Engineering Co. Ltd., has produced a modified Ferguson tractor only 44 inches wide for work between raspberry canes ; special implements include sprayer, discs and narrow trailer. Markham Traction Ltd., have produced a fertiliser distributor for mounting on the Fordson tractor.

Interesting developments in cow house equipment included a galvanised iron milking bail by Simplex Dairy Equipment Co. Ltd. The bail is mobile, accommodates two cows at a time and is equipped with auto recorder, vacuum cooler and strainer, sterilizing taps, steam injection washing tank, boiler, 1½ h.p. petrol engine : £525 with an oil-fired boiler. Gascoignes' showed the Mobilactor which is a self-propelled, self contained auto-recorder which can move down the cowshed with four milking units. The Gascoigne "Gascoignette" was an attractive barrow-type machine (with two units, £105) designed for 20-cow dairies ; it "enables Grandpa to milk at 90."

A one-man fully automatic pick-up baler (twine-tying) is being made by Powel & Co.; it can be adapted for use behind a combine harvester or threshing machine. A hand operated grain thresher (including rice) is being made by Tullos, Ltd. ; a 1–h.p. engine can be fitted. It measures 8 feet 10 inches by 4 feet by 4 feet and weighs only 4 cwt. Recent experience in Trinidad shows this machine to be capable of threshing 3,000 lb. of paddy per day when operated by two men.

A new idea in cultivation comes from McCartney and Miller ; it is a horizontal knife edge which passes underneath crops growing on banks. It is claimed that potato crops have been increased 10 per cent. It is called called the Sub-Drill Cultivator and can be made up for any tool bar. There seems to be room for local investigation in such methods of cultivation in tropical crops.

The agricultural performance of the Land Rover is of interest. In a 600 mile test in road work, cross country and farm operations the vehicle responded well. With 12 cwt. of sand ballast a 1 in 2.74 gradient was climbed easily in low second gear (in the 2nd of eight gears) : a cultivator at 6 inches deep and harrows were pulled in tandem at 4 m.p.h. ; and in ploughing two furrows to 7 inches the rate was ½ acre and 6.3 pints of petrol per hour.

VI. Education and Information

All farmers' advisory work in mechanization is handled in England by the N.A.A.S., and in Scotland by the three Colleges. The office of the Chief Machinery Advisor (N.A.A.S.) was visited, also the Edinburgh and East of Scotland College of Agriculture. At the former film strips, photographs and diagrams were examined ; at the latter the facilities for college courses in Agricultural Engineering were seen.

Kings College, Newcastle (University of Durham) was visited in connection with post-graduate training in agricultural engineering. A course is provided which leads to a M.Sc. degree, agricultural graduates being trained in engineering and engineering graduates in agriculture.

Special mention must be made of the Fordson Facilities School at Dagenham where visual aids and teaching methods were demonstrated. The

Ford Motor Company welcomes visitors as students at a few weeks' notice. The usual tractor courses are of three weeks, one week on the tractor, one on the hydraulic lift, one on the implements, but special courses are sometimes given by arrangement. Harry Ferguson Ltd. maintains a similar school near Coventry.

(Adapted from Report submitted by J.E.M. dated 9th November, 1949.)

HEAVIER WORK WITH LIGHT TRACTORS

THE ROADLESS NEWS. (Monthly) *Roadless Traction Limited, Gunnersby House, Hounslow, Middlesex, England.*

RESEARCH ON PNEUMATIC TYRES FOR FARM TRACTORS. *National Institute of Agricultural Engineering, Silsoe, Beds., England. Publication* 505/45. *Price* 2*s*.

EXPERIMENTS ON TRACTOR TYRE PERFORMANCE. *The British Rubber Development Board, Market Buildings, Mark Lane, London, E.C.* 3.

IT is becoming generally accepted that in the tropics more power is required for cultural operations than in temperate countries. This is especially so in land clearing and initial cultivations. When heavy equipment is not available, or where funds are limited, much can be achieved by middle-weight, or even light, tractors provided that they are appropriately equipped and skilfully operated. Speed, of course, must be forfeited, and in many seasonal operations speed is important—especially in the tropics. Nevertheless, lower capital investments, lower operating costs and more modest workshop requirements may go a long way to compensate for low power output. Much depends upon careful adjustment of implements and patient management. In many field operations it is not the average loads which are too great for light tractors, but the peaks to which the loads may rise owing to undulations or lack of uniformity in the soil. Standard wheeled tractors are frequently brought to a stop by wheel-slip rather than engine stall.

All who are concerned with the use of middle-weight tractors and vehicles for heavy jobs will be interested in *The Roadless News* which is published by the makers of the Roadless Half-Track conversion unit. Design features and practical experience, both agricultural and engineering, from all parts of the world are reported here. Articles have recently appeared on the loading of tractors, the use of dynamometers, and the groundnuts scheme, as well as copies of official test reports on the performance of Roadless equipment.

In *Research on Pneumatic Tyres for Farm Tractors* it is concluded that large diameter tyres and increased back axle weight are beneficial whereas no evidence was found that tyre section is important. Increasing inflation pressure above the minimum reduces efficiency. A range of reasonable practical values is given for the ratio: Minimum Working Drawbar Pull ÷ Live Back Axle Weight; for tyres with a minimum rolling radius of 22 inches the ratio is 0.40 or 0.45 to 1, and for tyres of m.r.r. 30.2 inches 0.55 or 0.60 to 1.

Further work by the British Rubber Development Board has led to conclusions relating to the drawbar performance of tyres on wide and narrow rims, the side-wall wrinkling of 11 × 36 tyres on W 10 rims, and the drawbar performance of water-ballasted 11 × 36 tyres on W 10 rims. In the latter connection it is shown that provided the total back-axle weight of a tractor is kept constant by the use of solid ballast, the performance of the tractor varies little with different amounts of water ballast. For any particular tractor (not keeping the total back axle weight constant) 95 or 100 per cent. water ballasting, as opposed to the usual 75 per cent., may be worth the extra trouble involved because of the extra back-axle weight provided by the additional water.—J.E.M.

MECHANIZATION IN AFRICA

Some Problems of the Groundnuts Scheme

In *Our World* (the Journal of the Overseas Food Corporation, Tanganyika) Vol. 2, Nos. 4 and 5, November and December, 1949, W. E. T. Bond, B.A., A.I.C.T.A., reviews some major problems of mechanization in the Groundnuts Scheme.

Most of tropical Africa has been worked over by peasant farmers at some time. For centuries the soil has been deteriorating and prosperous civilizations have disappeared into desert. If such destruction was caused by man working with rudimentary tools, how much more can be caused today with tractors and multiple ploughs. Serious damage has already been done in several parts of the world. The cause is known; so is the cure; but the knowledge is not widespread. The Overseas Food Corporation has a grave responsibility in Tanganyika where it is operating the largest mechanized project south of the Sahara.

In the areas which are being opened up due regard is given to the soil, vegetation and topography. Steep slopes are not cleared; roads are carefully sited ; and terraces are constructed soon after clearing. Often as much as 40 per cent. of an area cannot be used for agriculture. In spite of the high cost of working machines in narrow, curved belts along the slopes, contour cultivation is the rule.

Not only is soil a readily wastable asset, but so is fertility. Experience has shown the peasant that he can restore fertility in two ways: bush fallowing, and heavy manuring. Both are impossible in large mechanized undertakings. Experiments are necessary to find the factors limiting plant growth in the various soils covered by the Scheme.

Even basic methods of cultivation must be critically examined. Dry season ploughing or cultivation might be unnecessary if it were possible to plant, as the peasant does, quickly, when the soil is wet. Machinery is at a serious disadvantage here. Brief showers can immobilise tractors and planters.

Varieties excellent for peasants may not be suitable for mechanized production. In groundnuts a bush variety is necessary with nuts strongly attached to the vine so that they will not be lost by the mechanical digger. Selection will improve the Natal Common which is the most suitable of the

three brought in quantity to the Scheme. In some districts groundnuts must be planted early to reduce loss due to rosette disease. Natal Common is early-maturing and, after early planting, may ripen before the last rains and germinate in the ground. Other varieties are under observation.

Sorghums modified in the United States of America to suit combine harvesting have lost resistance to African diseases and pests. Pest control must be developed; or machinery must be adapted to suit the local giant varieties; or resistance must be bred back into the dwarf varieties. Sunflowers from Eastern Europe have been too uneven for combine harvesting, while Canadian varieties, bred for the combine, have given low yields.

Experiments show that planting on ridges rather than on the flat may increase the yield of groundnuts, even in a dry season. If the ridges are made along the contour they aid water and erosion control, but to be effective they must be large. Standard row-crop machinery is not designed for work on large ridges.

In East Africa the Overseas Food Corporation is evolving a new system of farming. Groundnuts and sunflowers (and, later, many other crops) are being grown on a bigger scale than anywhere else, and in different climate and soils. The system of agriculture cannot be made to suit machines designed for use under very different conditions elsewhere.

J.E.M.

MECHANIZED RICE-GROWING ON A LARGE SCALE

Report on the Mahaicony/Abary Rice Development Scheme to the 31st December, 1948 ; *Mahaicony/Abary Rice Development Scheme, Georgetown, British Guiana.*

It is becoming customary to view large agricultural development schemes, especially those involving mechanization, with mistrust. Experience has shown that in the early stages practice seldom matches expectations. This is probably because expectations are based on the observation of going concerns, and no amount of forethought can allow for all the local snags which will arise in any completely new agricultural scheme. Within reasonable limits, then, judgment must be delayed and deliberate. Two or three seasons of growing pains may seem agonizing at the time, but with the passing years speculation and comment peter out, and a project may become a comfortably established fact.

It was wise of the Board of Control of the Mahaicony/Abary Rice Development Scheme to report publicly on the working and future of the scheme only after many of the problems had been overcome. They were also, perhaps, fortunate that the origins of the scheme were part of the war effort and the work was initiated at a time when agriculture had little popular news value. The report covers the years 1942–48 and describes factually the early difficulties, the impressive progress which has since been made, and the future prospects of the Scheme.

It is not surprising that most of the snags were in drainage (on 11,000 acres the differences in elevation did not exceed 18 inches) and the techniques of operating the machinery. It is clear that problems of both cultivation and harvesting were overcome only after persistent trial and at considerable

expense. The difficulties were the greater owing to a lack of sufficiently experienced personnel to take charge of the maintenance of the machines. It is interesting that no mention is made of major structural modification of stock machines. Evidently means have been found of using standard equipment both for the local farmers' Hire Service and in the Scheme proper. Even in the mill all was not plain sailing, and a method had to be worked out to maintain plant efficiency in the drying of parboiled rice.

It is concluded that the ultimate success of the Scheme will depend much on the breeding of new varieties of padi suitable for mechanical harvesting. It is thought that cattle grazing and under-water cultivations will help with the control of weeds. It is considered that the problems of field and factory techniques have now been overcome and that the scheme can look forward with assurance that the capital investment will be fully justified. It is confidently expected that with a yield of 16 bags per acre, rice can be turned out of the mill at $7.50 per bag. The prices paid by the Rice Marketing Board range from $7.60 to $9.30. This is what we wanted to know. It is also a measure of the success of the Scheme.—J.E.M.

THE MECHANICAL EQUIPMENT OF FARMS

By J. C. Hawkins. *E. and F. N. Span, Ltd., London*, 1949. *Pp. XVIII*, 418. *Price* 21*s*.

In the *Countryman* Clyde Higgs writes ".....J. C. Hawkins has added yet another volume to those containing nothing very new or profound....." about farm machinery. This is true insofar as the list of contents and arrangement of the sections are not exceptional. In the treatment of his material, however, Mr. Hawkins has adopted a new approach, his assumption being that his reader, farmer or student, requires to know the more significant points in the selection and economic usage of implements rather than the variations in detailed construction of different types of machine. This approach is new, and Mr. Hawkins makes the most of it. The opening chapter on tractors, for instance, does not simply list tractor types and their features. After a discussion of desirable features in a tractor engine, the author describes the importance of suitable transmissions and wheel equipment, the correct loading, and the usage of tractors. The features of individual machines are entirely, and correctly, left to be found in manufacturers' catalogues and trade journals.

Certainly nothing very profound appears in the volume, but who would expect to find profundity of thought in what is so obviously intended as a general text for farmers and students ? For the student of agriculture the author's approach to the subject is ideal, although the student of agricultural engineering will find the work superficial.

The tropical agriculturist will again be disappointed at a book on agricultural machinery which limits its views to temperate agriculture. Equipment for land clearing ; the immense future for rotary cultivation in the tropics ; the use of machinery for soil conservation ; drainage and irrigation equipment ; these are a few of the subjects which are missing. Several sections of the book, however, along with the Appendix (giving tractor test data), the bibliography, and the world-wide list of institutions interested in agricultural machinery, are valuable.—J.E.M.

MISCELLANEOUS NOTES AND REVIEWS

THE ULTRA-ORGANIC SCHOOL

(*The following is reproduced—with permission—from* World Crops, *Vol.* 2, *p.* 2 (1950).—*Ed.*)

JUST which is the best way to grow a crop has, no doubt, been a matter of dispute and difference from the time man began to produce his food as well as hunt for it. Discussion and controversy are the very agents of progress. Nevertheless, there are times when some controversies would seem to have outstayed their welcome and outlived their usefulness, and this surely is the case with the extremist views of the so-called organic agricultural school. The 1949 meeting of the British Association had scarcely refocused public attention upon the world food and population problem when letters from members of this school began to appear in the Press condemning the very means by which Sir John Russell and other scientists had suggested we might avert a future Malthusian crisis.

It would seem that all we have to do to grow perfect crops is to limit the assistance we give our soils and plants to the provision of entirely organic manures. Seed dressings, insecticides, fungicides, all these are unnecessary ; for the purely organic system of nutrition will gradually confer upon our crops an almost complete immunity. These sweeping claims are made with an assurance that would ill become the true scientist, but it is, unfortunately, true to say that many people are likely to be misled by this superficial atmosphere of conviction. It has sometimes been suggested that it is better to ignore these outbursts, since counteractions merely give greater publicity to the extremists. This is the point of view of a diplomat who knows that he is in the wrong ; it is a ridiculous policy for those who are in the right.

The complete reply to the organic thesis is both lengthy and technical, and it can never be expressed in prose as vivid and colourful as that of the popular ' all-humus ' books and articles. Extremism and rhetoric go together ; logic and orthodoxy require more sober words and phrases. The layman who is not technically minded is unlikely to plough through a long vindication of scientific agricultural methods with durable enthusiasm. But short replies, pinning the organic extremists down upon their own ground, should and must be made. And for these tasks there is abundant material.

It is claimed that immunity to disease is attained when plant nutrition is based upon organic manures. Why, then, were the worst ravages of potato blight experienced in the hungry forties of the last century ? The Irish potato crops were grown upon manures at that time ; fertilisers were in their infancy, and they had certainly not crossed the Irish Sea in 1840. It is claimed that pests, including insects of which plants are the natural food, do not simultaneously attack those that are raised by organic methods ; it is also claimed that such plants are far more nutritious as food for man and his animals. There is surely a paradox here that demands rational explanation.

How odd and convenient that the same material which is less palatable to one class of consumer should be more palatable to the desired consumers! It is worth noting that only one of the leading advocates of organic cropping has attempted to resolve this dilemma and the ingenious argument then presented was that insect pests were so quickly satisfied in their invasions of the organic-fed crop that the damage caused was inappreciable.

The words 'organic' and 'biological' are invested with almost sacred righteousness, while the word 'chemical' is treated as if it were itself an accusation. Yet every green plant is the very bridge between the inorganic and organic world. Plants live by the assimilation of simple inorganic ions and by the photosynthesis of carbon from the air's carbon dioxide; and these ingredients are built up into complex organic molecules which then support higher forms of life. Who, realising this, can presume to distinguish disparagingly between a class of plant food that is 'organic' and another class that is 'chemical'? This school of thought has frequently denounced field and plot tests on the grounds that only a part of the total process of plant growth is studied. Could any doctrine be more open to the charge that a part is mistaken for the whole than this dogmatic opinion that all crops should be exclusively grown upon organic forms of food? This controversy is almost as obsolete as the Phlogiston theory of combustion and it should be exposed more vigorously.

VERNALIZATION AND PHOTOPERIODISM

A symposium by A. E. Murneek and R. O. Whyte with the collaboration of numerous other authors, and with a foreword by K. V. Thimann. Published by "Chronica Botanica", Waltham, Massachusetts, U.S.A.: Wm. Dawson & Son, London, W.C. 2. Price $4.50.

This stimulating publication will be welcomed by plant physiologists, agronomists and botanists in general. It consists of critical reviews from well known authors, of various aspects of the physiology of flowering: in particular as the title implies it is concerned with vernalization or pre-treatment of seeds or seedlings at conditioning temperatures and humidity and photoperiodism or the influence of the length of exposure to light and darkness on growth and reproduction. R. O. Whyte's chapter on vernalization brings up to date the excellent bulletin on this subject published by the Imperial Bureau of Plant Genetics in 1933. The various papers on Photoperiodism and on Thermoperiodicity link up with Vernalization in casual relationships with the developmental physiology of plants. These aspects which were formerly regarded as distinct can no longer be separated from each other and now have to be considered integral parts of the complex of environmental factors in the physiology of flowering. In spite of the considerable volume of work that has been carried out on these subjects, it is obvious that only the fringe of the fundamental problems involved has, as yet, been clarified and as K. V. Thimann states in his introductory passage the stage of the field is such that a single clear-cut result might change its whole aspect overnight. Even were this to happen it would detract little from the intrinsic value of this able review of the subject. The wealth of information provided and the implications of the facts presented require active concentration of mind

and thought and provide admirable material for training in scientific thinking. It is certainly not a book that should be picked up for leisurely reading.

An attempt has been made to give full weight to current viewpoints on the various aspects of this intriguing subject. This has been largely accomplished but the reviewer is, however, doubtful whether it has been completely achieved. The proponents of the view that the level of phytohormones or auxins may be intimately concerned in the initiation of the flowering process and that this level differs widely in different plants have not in the reviewer's opinion had " an adequate hearing ". The evidence for this, which was strongly supported by recent work on the flowering of pineapple has now been greatly strengthened by Leopold and Thimann's recent work on the effect of auxin on flower initiation (*Amer. Journ. Bot.* 36 : 4 : p.342. April, 1949). A general discussion of this phase of the problem is contained in K. V. Thimann's book *The Physiology and Chemistry of Hormones*, Chap. 3. (*The Academic Press.* New York 1948).

Although British work has been well summarized by R. O. Whyte one misses the critical discussion which the leader of the British school of research workers on this subject, Professor F. G. Gregory, might have contributed. The latter has recently formulated what appears to the reviewer to be the most likely working hypothesis of the physiological basis of flowering in so far as it is possible to formulate such a hypothesis from the evidence at present available. This has been incorporated in the symposium on Growth recently published by the Society for Experimental Biology. Indeed this publication could with profit be read in conjunction with the symposium at present under review. The average English-speaking reader would probably have appreciated the translation of the special supplements by E. Bunning and A. Lang into English.

These suggestions might be given consideration if a revised edition should be decided upon at any future date : however, the subject is developing relatively rapidly and it is probable that fundamental progress would have been made in many phases of the subject by the time it is ripe for a further review.—H.E.

RICE DISEASES

Manual of Rice Diseases BY G. WATTS PADWICK, *Commonwealth Mycological Institute*, 1950. *Pp.* viii + 198. *Price* 30*s*.

PART I of this book deals with diseases of parasitic origin ; Part II with non-parasitic diseases, and Part III is an annotated check-list of all the fungi recorded on rice.

In this comparatively short account (Part I, which is the largest section, only runs to 115 pages) the author has comprehensively and impartially reviewed the literature of all the most important diseases of the crop. All too seldom, however, does he sum up and give his own opinion as to the importance of the disease and the practicability of the control methods reviewed.

In his preface he hopes ' that the few figures given, and the long list of fungi recorded in the annotated check-list of fungi on rice, will dispel any illusions that the crop does not suffer seriously from diseases '. This the

book entirely fails to do. It leaves one with the impression that although an impressive list of fungi has been compiled, the great majority of them are of no importance, and that even the more important ones may be not worth controlling or may be impossible to control economically. It is surely significant that in many instances control by plant breeding has made little progress, although an annual crop such as rice should present few serious difficulties and rapid progress might have been expected.

It is, however, of great value to have the diseases of a crop summarised in this way and Mr. Watts Padwick is to be congratulated on having dealt with rice in such a straightforward and readable manner—R.E.D.B.

PLANT VIRUSES AND VIRUS DISEASES

By F. C. Bawden, M.A., Dip. Agric., F.R.S. (*3rd Edition*) *Waltham, Mass. : The Chronica Botanica Co. ; London, W.C.* 2 *Wm. Dawson & Sons, Ltd. Pp.* xvi + 335, *frontispiece, vignettes and* 59 *text-illustrations. Price* $6.00 (U.S.)

Loss of the type of the first (1939) edition, during the invasion of the Netherlands, necessitated publication, in 1943, of a second, revised in the light of progress in plant virus work during the intervening period. Since during the past seven years there has been a further steady advance in almost every aspect of the subject, the third edition contains one new chapter and many new illustrations, while the text has been almost entirely re-written and the order of presentation of material slightly altered. Thus, as the author's preface states, although the same general format has been maintained this is largely a new book rather than another edition.

An introductory chapter is followed by an account of external and internal symptoms produced in plants by different viruses. No attempt is made to provide a catalogue of described plant viruses, for which the reader is directed elsewhere ; nevertheless, there must be few well-authenticated ones that do not receive some attention. Chapter 4 deals with methods of transmission, and Chapter 5 with the relations between viruses and their vectors. The author considers that earlier evidence for the multiplication of certain viruses in their insect vectors is inconclusive, but in an addendum he accepts the recent work of Black on clover club leaf as proof that this virus, at least, can maintain itself indefinitely in its vector (*Agalliopsis novella*). (Black showed that from one infective insect the virus could be transmitted through the eggs for 20 successive generations).

There follow chapters on virus strains, and the use of serological reactions in the study of plant viruses. Chapter 8, the new one, gives a detailed account of quantitative methods of assaying for viruses, involving the correct application of local lesion counts and serological precipitin tests. Subsequent chapters deal fully with the purification of viruses, the chemical, physical and crystalline properties of these purified preparations, measurement of particle size, and different types of inactivation. Chapter 14 discusses the vexed question of virus taxonomy. The author condemns attempts to set up systems of classification based primarily on host reactions, considering that groups should be based, mainly, on fundamental characters of the virus particles ; if, for any virus, a reasonable amount of information is lacking, no attempt should be made to classify it with better known ones. After

consideration of the effect of infection on host plant physiology, and the control of diseases due to viruses, the book concludes with a chapter on their possible origins.

Appropriate lists of references are appended to each chapter, and there are adequate General and Author Indexes. The book is of great value for its up-to-date, critical correlation of the scattered information on the many branches of virus work. The illustrations are excellent, the numerous vignettes pleasing, and the arrangement and printing good. A few typographical errors occur : e.g. " stem " sterilisation, page 77, line 46 ; " Rosacea ", page 226, line 29.—W.T.D.

HYBRID MAIZE

An interesting article on this subject, by E. S. Bunting, B.Sc., of the Department of Agriculture, Oxford University was published in " World Crops " Vol. 2, pp. 5–9. The Summary, and the Conclusions, are as follows :—

Of all the cereals maize is capable of giving the highest yields, and accordingly is of great potential importance in a world of rapidly growing population. Chiefly grown in the U.S.A., where its principal use is feeding livestock, it is also widely grown in many other countries, in some of which it is the staple food.

Of late years the introduction of hybrid seed has greatly increased yields and opens up possibilities of more extended production.

The limits of the yields that can be obtained from maize under ideal conditions has been the subject of recent research. In the Columbia River Valley, U.S.A., irrigated hybrid maize which has received 5 acre-ft. of irrigation water and manurial dressings conveying 150 lb. of nitrogen, has yielded no less than 193 bushels of grain per acre or nearly 5 tons ! No other cereal crop can approach this yield potential ; consequently, maize must play an important rôle in helping to mitigate present and future world food shortages.

THOMPSON'S ELEMENTARY VETERINARY SCIENCE

Revised by A. C. Duncan. *Bailliere, Tindall & Cox, London,* 1949. *Pp. VIII.* 474. *Price* 15*s.*

The original book by Henry Thompson, Lecturer in Veterinary Science at the Aspatria Agricultural College was published in the form of twelve lectures with three appendices A, B and C and 54 illustrations and was really intended as a text-book for agricultural students taking a veterinary course.

The lectures dealt with (1) General Disease Conditions, (2) Bones, (3) Muscles, (4) The Foot and Shoeing, (5) Respiratory Organs, (10) Nervous System, (11) Skin and (12) Urinary and Generative Organs, each lecture covering the anatomy, physiology and diseases of the various systems.

The appendices dealt with (1) Synopsis of Diseases, their recognition and first aid treatment, (2) Medicine Formulae and Diseases and (3) Various forms of manual aids.

The present book revised by A. C. Duncan a Lecturer in Veterinary Science at the Royal Agricultural College, Cirencester, is the sixth edition and

was published in 1949 in a form that will meet the requirements not only of agricultural students doing a veterinary course but also farmers and stock-keepers.

The book is now made up of seventeen chapters and the new additions are three chapters (1) on Hygiene, (2) Foods and Feeding and (3) Poultry diseases. These new additions have helped to make the book much more complete for all those who have to carry out the management of animals and their first aid treatment and it should prove a valuable addition to the Library of anyone interested in Animal Husbandry.—H.V.M.M.

TROPICAL SANITATION

MANUAL OF PRACTICAL TROPICAL SANITATION BY J. BALFOUR KIRK, C.M.G., M.B., CH.B., *Second Edition, London: Bailliere, Tindall & Cox* 1949. *Pp. VIII*—288, 46 *figs. Price :* 10*s.* 6*d.*

THIS is an excellent book for Agricultural Officers whose work brings them into contact with labour forces. It gives a clear and concise idea of tropical hygiene and preventive measures against disease. In outlying districts where technical aid is not easily obtained this book would be an asset, and would enable any young officer to give sound advice on many practical matters pertaining to the lay-out of a village and its hygienic requirements.

—M.V.F.G.

AGRICULTURAL SCIENCE IN THE SUDAN

BY R. L. KNIGHT & B. M. BOYNS, (*T. Buncle and Co., Ltd., Arbroath. Price :* 20*s.*)

A bibliography with abstracts. Within the compass of 251 pages the authors have surveyed the literature of the extensive field of agricultural science in the Sudan and given to us an invaluable work of reference. This book should be available to every agricultural scientist in the dry tropics. It is to be hoped that the authors' example may stimulate the production of similar bibliographies in other regions.

C.W.L.

THE PRODUCTION AND UTILIZATION OF SILAGE

A Review of World Literature in Abstracts. Bulletin No. 40 of the Commonwealth Bureau of Pastures and Field Crops, Penglais, Aberystwyth, Great Britain, 1949. *Price* : 10*s.*

A mine of valuable information upon all aspects of silage, consisting largely of collected abstracts brought under one cover which have previously appeared in Herbage Abstracts, Nutrition Abstracts and Reviews, and Dairy Science Abstracts. Full indexes are given under Authors, Genera and Animals. The bulk of the abstracts refer necessarily to work in temperate climates and the tropical worker must take time to select out references applicable to his conditions.—C.W.L.

COMMUNICATIONS ON ORIGINAL INVESTIGATIONS

THE IMPROVEMENT OF YIELD IN THE TUNG OIL TREE (*Aleurites montana*)*

By

C. C. WEBSTER

(*Tung Experimental Station, Department of Agriculture, Nyasaland*).

AUTHOR'S SUMMARY

PART I

Variation in Seedling Plantations

A study of variation in seedling plantations has largely confirmed the findings of other workers but has added to, or modified, them in some respects. As regards flowering, it is found that 40 to 50 per cent. of the trees are predominantly male while the remainder, known as "bearers", produce a much higher proportion of female flowers. The types of inflorescences commonly found are described. The predominantly male trees are readily distinguished from the bearers and, although there is certainly appreciable seasonal variation in the proportion of male and female flowers borne by individual trees, no case has been observed where there has been a change from the predominantly male to the bearer type or *vice versa*. No evidence has been found to support the suggestion made by workers that the proportion of predominantly male trees in a seedling plantation is affected by soil, climate or altitude and it is concluded that it is a genetic feature. The blossoming period of predominantly male trees is divided into a male phase followed by a small female phase while the bearers normally produce only female flowers at the beginning of the season and then open males when most, or all, of the female flower is over. Although these phases may overlap to some extent it is evident that the trees are mainly cross-pollinated.

Predominantly male trees consistently give low yields which increase only slightly with age. Amongst the bearing trees there is great variation in yield, the majority being poor to moderate croppers and a small proportion giving really heavy yields. Variation in the percentage of seed in the fruit, percentage of kernel in the seed, &c. has not been studied to any extent but the small amount of work done indicates that variation in such characters is very much less than it is in yield.

Two main types of tree have been found. In type A the main trunk continues growth indefinitely and produces whorl after whorl of primary branches one above the other, secondary, &c., branches arising at relatively long intervals on the primaries. With type B trees the trunk usually ceases to exist above the first or second whorl of primaries and secondaries arise at short intervals on the main branches with the result that a low, dense, bushy

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tree is produced. Generally speaking, under similar conditions of soil, etc., type A trees are more vigorous in growth and less precocious in fruiting than B types and the weaker individuals of the latter type tend to reach peak fruit production relatively early in life and may subsequently decline markedly in yield.

Selection of Desirable Mother Trees

The selection of the best bearing trees in seedling plantations and their vegetative propagation by budding or some other method, obviously offers great possibilities of improving yields per acre. Selection has been carried out by surveying plantations totalling over 52,000 trees, numbering individual trees which appeared to be carrying a heavy crop, and recording their yields for several years. Yield of dry seed has been the chief criterion for selection but observations have been made on vigour and habit. The work of selection has been handicapped by the fact that in 1940 there was only a small acreage in bearing and because working with immature trees has probably led to a tendency to select for precocity.

PART II

Propagation of Selected Trees as Buddings

It is evident that final selection must be based on the performance of the budded progenies in replicated clone trials. After several years of yield recording the best of the provisional seedling selections are being propagated as buddings for trial and so far 100 clones are under test, but many of these are not yet in bearing.

Buddings have consistently given higher yields than ordinary unselected seedlings or than seedlings raised from open pollinated seed taken from the same mother trees as the buddings are derived from. Growth and size of buddings is significantly less than that of seedlings, and, as there is a positive correlation between size of tree and yield, this is one main reason why budded clones do not give, age for age, yields as high as their seedling mother trees. Another cause is probably to be found in the effect of variable seedling rootstocks.

The use of *Aleurites fordii* as a rootstock is not advantageous since it has a marked dwarfing effect and gives lower yields than the *montana* stock.

Variation in yield, vigour and habit between clones

Despite the fact that some variation within a clone must necessarily be introduced by the use of seedling rootstocks, certain characteristics of the mother trees are reproduced with considerable uniformity in all the buddings derived from them. Buddings from A–type mother trees are invariably A–type while B–type mother trees give rise exclusively to B–type buddings. Moreover the differences between the two types are to some extent emphasised by budding. All B–type clones so far grown are less vigorous than A–types, the reduction in vigour due to budding being most marked in clones derived from B–type mother trees which are weak or slightly less than medium in vigour, such clones being very weak or even dwarf. Precocious fruiting is a well marked characteristic of all B–type clones and is particularly noticeable in the weakest clones which often fruit one year after budding. These dwarf

B–clones quickly reach a peak in fruit production and thereafter remain steady for several years or begin to decline in yield; they also tend to over-crop with the result that biennial bearing may develop and shoot die-back occur. The B–clones which are medium, or slightly less in vigour, have continued to give increased yields up to the 8th year but are expected to reach peak production relatively early and may thereafter decline, while the single B–clone observed which is stronger than medium in vigour may continue to increase in yield over a longer period. Except for the weakest clones, the B–types have given higher yields than the A–clones over the first eight years when planted on reasonably good soil. The latter are expected to increase in yield for some years and will probably out-yield most of the B–types in due course.

Owing to the long term nature of the crop it is not yet possible to say which of the two types of clone will prove the more useful or which individual clones are best. It is probable that it will be found advantageous to use a mixture of the two types, planting the A–trees at a relatively wide spacing and interplanting with the quicker cropping and smaller B types which can be cut out in due course as the former mature and require all the land; but the possibility of using some of the stronger B–clones as permanent trees at a suitable spacing cannot be excluded. Most of the clones for which 5 years', or more, yield records are available result from early selections, when the survey of seedling plantations was limited, and it is likely that better results will be obtained from the newer clones than from most of the old ones. As far as can be judged at present the older clones include two really good A–types and three really good B–types.

Variation between clones in certain fruit characters

There are significant differences between clones in mean seed weight, percentage of seed in fruit, percentage of kernel in seed, and percentage of oil in seed and kernel, but no significant differences were observed between buddings of the same clones of *montana* and *fordii* rootstocks except in respect of mean seed weight. No significant correlations were observed between these characters and yield. The variation in the fruit characters studied is very much less than it is in yield, which is obviously a far more important criterion of selection, and the order of merit of clones is unlikely to be altered from that obtained on a dry seed basis if yields are converted to lb. of oil. The differences between clones in oil content may nevertheless be sufficient to be of economic importance and a more detailed investigation in which the highest yielding clones are compared and the effect of season and manuring on oil content, &c., are studied, is necessary.

Variation between clones in flowering and fruit setting

There are significant differences between clones in the mean numbers of female flowers, fruit and seed per cluster, percentage of female flowers setting fruit, number of seed per female flower and number of seed per fruit. Seasonal differences within clones are appreciably less than the differences between clones in any season. Certain clones are more efficient than others as they have a higher percentage set of fruit and better field fruits. Possible correlations which may exist between these characters and yield could not be studied from the data available as the size of sample used was too small to characterise individual trees with sufficient accuracy.

With the majority of clones there is a period during the early part of the blossom season when only female flowers are opened and although all clones later produce some male flowers some of them do so in insufficient amount for full pollination. It is therefore necessary to provide pollinators in the shape of selected early flowering predominantly male clones which have a long blossom period. The proportion of such pollinators which is required has not yet been precisely determined but the evidence suggests that pollen will be adequate if budded plantations (*a*) contain 5 per cent. of such pollinators, and (*b*) are polyclone.

Propagation of root-stocks

In small scale experiments attempting to propagate trees on their own roots with a view to using clonal root stocks no success has been obtained with stem cuttings. Rooting has been obtained by stooling and layering but neither method is really practicable for propagating selected material. Although a high percentage of *A. fordii* root cuttings from either young or mature trees produced plants, only moderate success has so far been obtained with *montana* root cuttings from young seedlings and a low percentage of plants from material from mature trees.

PART III

Improved Types of Seedling

Although the open-pollinated seedling progenies from certain mother trees may contain a fair proportion of individuals true to type as regards habit of growth, and the bearers may give quite good average yields, it seems probable that such progenies will most usually give yields inferior to buddings from the same mother tree. Planting open pollinated seedlings from good trees and then budding the males is not likely to be sound, and selection from such material is considered to be less likely to result in improved planting material than selection from legitimate seedling families.

"Clonal seedlings" raised from seed taken from isolated gardens of buddings are under trial as it was thought possible that such seed might give rise to a high yielding stand of trees. This material contains only 28 per cent. of predominantly male trees. Only one crop has so far been harvested from these trees and yields were less than those from buddings of a standard clone planted with them.

Legitimate seedling families have been produced by selfing, or crossing between selected mother trees, or the clones derived from them, with a view to producing new and superior clones by budding from the outstanding individual bearers which it is hoped to find amongst them. The percentage of predominantly male trees in the different families ranges from 18.7 to 42.8 with a mean of 26.1, and early yields indicate some very promising individuals amongst the bearers.

Hybrid *A. montana* × *A. fordii* seedlings, produced by crossing between good trees of both species, have been found to be mostly entirely staminate, and the small proportion which bear female flowers have so far given negligible yields of fruit.

PART IV

Cultural and Manurial Experiments

The early results of the few experiments on cultivation and manuring have so far merely indicated the need for reasonably good cultivation, especially in the early years, and the importance of maintaining available nitrogen supplies. The good start obtained by trees given thorough cultivation accompanying inter-cropping with soya beans for the first four rainy seasons continued to exert a beneficial effect on yields and growth up to the eighth season. Inter-cropping with a crop which takes little from the soil is likely to be the best and most profitable system during the first 3 or 4 years in a tung plantation, but there are indications, which will require confirmation, that satisfactory growth of the trees may be obtained even if cultivation is reduced to circle weeding, provided that grass between the rows is slashed twice a year, placed as a mulch around the trees and a dressing of nitrogenous, fertiliser given. No experiments have been made with older plantations but in such annual inter-cropping is precluded and cultivation is likely to consist either in periodic discing and/or mowing of grass and weeds, possibly combined with mulching, or in the establishment of a permanent leguminous cover crop. Nitrogenous fertiliser will almost certainly be required in addition, as marked responses in both yield and growth have been obtained from nitrogen, and trees on estates frequently develop symptoms of deficiency of this element after several years in bearing. No response has yet been observed to phosphate or potash but trials have only run for 3 or 4 years and it is quite possible that application of these nutrients may later become desirable, especially if increased yields are induced by regular nitrogen fertilisation.

1. VARIATION IN SEEDLING PLANTATIONS AND THE SELECTION OF DESIRABLE MOTHER TREES

INTRODUCTION

1. The work here described was begun in the 1940–41 season and has been carried out at the Tung Experimental Station, situated at approximately latitude 15° 50′ S and longitude 35° 10′ E; at Zomba some 40 miles to the north-east; and on estates in the Cholo District, a few miles south of the Tung Station. The altitude of the Tung Experimental Station is 3,880 feet a.s.l. and that of Zomba 3,040 feet a.s.l. Rainfall at the Tung Station over the 8 year period November 1940 to October 1948 has averaged 51.26 inches per annum of which 46.88 inches fell in the wet summer season of six months from November to April and 4.38 inches in the cool winter season. Rainfall in most of the Cholo District is slightly higher than that of the Tung Station; at Zomba it is about the same, comparable average figures to those just quoted being 51.6, 46.8, and 4.8 inches.

2. *Aleurites montana* is a deciduous species and in Nyasaland the dormant period of the trees is broken at the beginning of the warm season in September and the new leaves and flowers are produced, and fruit set, before the rains break. Growth continues through the wet summer months, the fruit ripens and falls in April and May, and in the latter month the leaves are shed and the trees remain dormant through the cool winter season.

3. Work on yield improvement has followed the customary two main lines of investigations:—(*a*) the production of improved planting material, and (*b*) cultural and manurial experiments. The production of improved planting material has been attempted in the following stages:

(i) A study of the variation in seedling plantations.

(ii) The selection of desirable, high-yielding mother trees from seedling plantations.

(iii) The propagation of selected mother trees on seedling rootstocks and the testing of the resulting clones.

(iv) Minor work on the propagation of trees on their own roots aiming ultimately at the use of clonal rootstocks.

(v) The observation of families of open pollinated seedlings derived from high-yielding trees and their comparison with buddings.

(vi) The production of legitimate seedling families by selfing, or crossing between, selected high yielders or the clones derived from them. It is hoped that amongst such families certain outstanding individuals will be found from which new and superior clones can be made by vegetative propagation.

(vii) The testing of "clonal seedlings", raised from seed produced by natural pollination in isolated monoclone and multiclone plots of buddings.

With a long lived perennial species it is inevitable that some years must elapse before conclusive results can be expected from investigations of this nature and the work done so far is therefore merely a beginning. This applies most particularly to items (v), (vi) and (vii) above. Cultural and manurial experiments, which could not be begun effectively until more or less standardised budded trees were available, are as yet at a very early stage.

Variation in Seedling Plantations

Flowering

4. The occurrence of three normal types of inflorescence was reported by Wit (1939) and a fuller description has been given by Webster (1944). These types are :—

(i) *Male inflorescences* which emerge simultaneously with the new leaves when the compound terminal buds open at the end of the dormant season so that the individual flower buds can be seen forming a dense, closely-packed head as soon as the bracts of the terminal bud are opened. When fully developed the inflorescence is a large much branched *paniculate cyme* and commonly carries 200 or more male flowers. By the time the flowers open the shoot bearing the inflorescence has grown out a few inches.

(ii) *Female inflorescences* which are borne at the end of a short leafy shoot of the new season's growth and do not become apparent until this shoot has grown out several inches. These inflorescences are smaller and denser than the male clusters and contain, on an average, only about 20 flowers.

(iii) *Mixed inflorescences.* Although some intermediate forms occur these are usually of one of two types. (*a*) On predominantly male trees quite often the flowers borne at the ends of the main branches of the large cymes are female, and these inflorescences therefore contain 200 or more male flowers and from 1 to 5 females. The female flowers are always the first to open in the cluster but for some unknown reason they never set fruit. (*b*) A second type, rather uncommon on predominantly male trees but common on " bearers ", has the same structure and mode of production as the purely female inflorescences. Normally there is a predominance of female flowers and the males are borne in subsidiary positions. Usually the female flowers are all over before the males open but there is sometimes overlapping in the time of opening of the latest females and the earliest males.

The buds of individual male and female flowers are easily distinguishable before they open, the former being oval in shape and the latter conical and larger.

5. Reteaud (1938) observed in Indo-China that although male and female flowers normally occurred on the same tree a number of individuals had far more males than females, the proportion of males sometimes being as high as 98 per cent. He stated that the proportion of flowers of the two sexes is influenced by altitude and soil fertility, and also that a "normal quantity" of female flowers is sometimes found on trees which in previous years have been almost entirely without them. Another worker in Indo-China (*International Institute of Agriculture*, 1938) studied the flowering of a plantation of 599 trees in 1929 and 1930 and reported that in these two years 22.8 and 29.5 per cent. of the trees were entirely male and 44.8 and 45.3 per cent. had less than 5 per cent. of female flowers. In both seasons over 30 per cent. of the trees had over 95 per cent. of female flowers and there was therefore a tendency for the majority of the trees to be predominantly male or female. Hornby and Cormack (1937 and 1938) made observations on a plot of 128 trees for four seasons when the trees were from 3 to 6 years old and their figures showed that the percentage of entirely male trees varied from 11.9 to 23.8 in different seasons and that of entirely female trees from 46.7 to 73.1. Wit (1939) also observed a tendency for the trees to be either predominantly male or female in Java.

6. The writer has made no quantitative study of the tree to tree variation in proportion of male and female flowers but close observation of six plots of seedlings, totalling 1,975 trees, over periods of up to 10 years, have led to conclusions slightly different from those recorded above by previous workers. In these, and all other seedling plantations examined, a proportion of the trees, varying from 40.1 to 54.1 per cent., are predominantly male and bear only a little fruit. These trees are readily distinguished from the others, particularly at flowering time, as nearly all their flowers are produced in the large male clusters described above and their bloom is therefore much more profuse and showy than that on the other trees. A small proportion of female flowers is also borne on these trees either in central positions on the large predominantly male mixed clusters, in which case they are amongst

the first flowers to open but set no fruit, or else in separate female or mixed clusters (of type 3 (*b*) above) which are not usually opened until the peak of male blossom production is past. Apart from the opening of females in the type 3 (*a*) clusters, which usually occurs only over a very short period at the beginning of the season, a tree of this type normally has a long male flowering phase followed by a short period when females are opened after most, or all, of the males have fallen. The actual proportion of female flowers on these trees has not been studied but the yield records indicate that it varies from nil, or practically nil, to quite a lot and also varies appreciably from season to season. Yields from these trees, even when over 10 years old, very rarely exceed 10 lb. of dry seed and normally average only 3 to 4 lb.

7. The remainder of the trees, which will be referred to as "bearers", produce an appreciably greater proportion of female flowers, although it is possible that an actual count of flowers might show that some of them are not in fact predominantly female. At the beginning of the blossom season they normally only open small female inflorescences, later mixed clusters and/or a few purely male clusters may be opened. Male flowers are not usually opened until the majority of the female blossom is over and there is therefore a female phase followed by a male phase, although in many trees these overlap to some extent and a few trees have been noticed which open a small proportion of male flowers quite early.

8. No seedling tree has yet been observed which, *over a period of several years*, has produced flowers of only one sex and it is concluded that in Nyasaland the species is really entirely monoecious. It is suggested that the considerable proportion of trees bearing flowers of only one sex recorded from Indo-China (*International Institute of Agriculture*, 1938) and from Nyasaland (Hornby and Cormack, 1937 and 1938) may have arisen because observations were not made sufficiently frequently or accurately during the course of the blossoming season and therefore a small number of flowers of the "minor" sex, which were probably produced late in the season, was not observed. Observations made in Nyasaland on plots at altitudes ranging from 2,800 to 3,880 feet above sea level have produced no evidence in support of Reteaud's (1938) suggestions that the proportion of predominantly male trees is influenced by altitude and it is noteworthy that the mean percentage of predominantly male trees in the six plots of 1,975 trees is 45 per cent.,—c.f. the figures of 44.8 to 45.3 per cent. quoted above from Indo-China. No indication has been found that soil conditions affect the proportion of male trees. Furthermore, heavy applications of manure to predominantly male trees has not affected the nature of their flowering, nor have bearing trees switched over to the predominantly male condition when they have obviously been starved on poor soil in competition with grass. In all the plots observed the same trees have consistently been predominantly male, or of the bearer type, each year over the whole period and although there is undoubtedly appreciable seasonal variation in the proportion of male and female flowers on many trees no case has been observed where there has been a change from one type to another. There is thus a well marked division into predominantly male and bearer types which appear to be a genetic feature, and although a certain number of intermediate types are found, these are very few.

Yield

9. From the nature of the variation in flowering habit already described it is evident that in any seedling plantation there must necessarily be very considerable tree to tree variation in yield. This has been noted by all workers elsewhere, (Reteaud, 1938; Toxopeus et. al., 1939; Larroque, 1939; Engelbeen, 1946) but published yield data of any kind is extremely scanty. A considerable body of yield records has been accumulated in Nyasaland, typical of which are the yields from a plantation of 544 seedlings at Zomba where individual tree records have been kept over a period of years.

(Table 1). The figures represent the combined data from several groups of trees planted contiguously over an area of approximately 10 acres but belonging to several age groups. In one year a severe hailstorm which occurred just at the time of flowering and fruit setting very greatly reduced yields and the records for this season have therefore been omitted from the table. Frequency distributions according to the yields at 5, 7 and 10 years old are given in Table 2. It will be observed that the predominantly male trees, which form 41.54 per cent. of the total population, have consistently given low yields which increase only slightly with age. Even at 10 years old the majority of the predominantly male trees have given less than 5 lb. of dry seed, and only one such tree yielded over 15 lb. Amongst the bearing trees there is great variation in yield which increases in range with age as more and more bearers pass into the higher yield groups. The majority of the bearers are poor to moderate yielders and only a small proportion give really heavy yields. Thus, in the tenth year, 63.52 per cent. of the bearers (37.13 per cent. of total population) yielded between 10 and 30 lb. dry seed and only 6.59 per cent. (3.85 per cent. of total population) gave over 50 lb. Yields of individual trees vary a good deal from year to year, as may be seen from the figures given for some selected trees in Table 5, but it has been possible to select a number which are fairly consistently high yielders. The highest yield so far recorded in Nyasaland was obtained from one of the Zomba trees which in one season gave 125.2 lb. dry seed.

Table I. *Yields of 544 seedling trees at Zomba, lb. of dry seed*

Age Years	Number of trees			Yield per tree			Yield per acre, all trees
	Males	Bearers	Total	Males	Bearers	All trees	
5	226	318	544	0.9	9.2	5.8	325
6	226	318	544	1.5	11.8	7.5	420
7	186	263	449	2.2	16.2	10.4	582
8	134	199	333	2.5	20.2	13.1	734
9	203	288	491	3.8	23.0	15.0	840
10	226	318	544	3.9	23.8	15.5	868
11	203	279	482	3.3	23.2	14.9	834

TABLE II. *Frequency distribution of 544 seedling trees according to yield*

Yield, lbs. dry seed	0–	5–	10–	15–	20–	25–	30–	35–	40–	45–	50–
Percentage of trees :											
at 5 years old ...	64.36	16.29	9.37	6.31	2.24	.81	.61	—	—	—	—
at 7 years old ...	46.69	16.36	12.13	9.37	5.33	4.41	2.02	2.39	.18	.55	.37
at 10 years old ...	32.54	15.07	13.42	9.74	5.88	6.80	4.23	3.49	3.31	1.65	2.02

Yield, lbs. dry seed	55–	60–	65–	70–	75–	80–	85–	90–
Percentage of trees:								
at 5 years old ...	—	—	—	—	—	—	—	—
at 7 years old ...	.18	—	—	—	—	—	—	—
at 10 years old ...	.55	.55	.18	—	.18	—	—	.37

10. As a matter of interest the yields from the oldest trees at Zomba (123 planted in December, 1931), which are also the oldest specimens of *A. montana* in Nyasaland, are shown in Table 3. It is not known when trees of this species reach their peak yield or how long they remain in bearing, but the latter is probably a period of many years as I have seen semi-wild trees in Burma which were at least 35 years old and were still bearing heavily, and HOH (1939) states that they may live to 100 years and usually reach peak production at between 25 and 30 years old. In Table 3, the decline in yield after the highest yield was recorded in the 13th year (which followed a season in which yield was greatly reduced by hail damage) is believed to be due to deterioration in soil fertility, which has very definitely occurred, but at present it is impossible to rule out entirely the possibility that it may be partly due to the trees having passed their natural production peak. The yields of Tables 1 and 3 are representative of those generally obtained from seedling plantations under fairly good conditions of soil and cultivation in Nyasaland.

TABLE III. *Lbs. air dry hulled seed*

Age—years	123 TREES		
	Yield per tree		
	Male 48	Bearers 75	All
3	0.1	2.7	1.7
4	1.0	5.9	3.6
5	0.5	8.2	5.2
6	1.2	14.6	9.4
7	2.0	18.1	11.8
8	2.3	21.1	13.7
9	2.7	23.1	15.1
10	5.2	30.4	20.5
11	5.1	27.4	18.7
12	3.9	11.5	8.5
13	6.3	32.9	22.5
14	5.1	21.4	15.0
15	3.5	21.5	14.5
16	1.8	16.4	10.7

Fruit characteristics

11. Variation in the percentage of dry fruit, percentage kernel in seed and percentage kernel in fruit has not been studied in Nyasaland for the reason that facilities and staff have not been available for determining the oil content of seeds and without taking this last factor into consideration little or no benefit could be obtained from studying the other characters. A small preliminary investigation of the variation in the percentage of air dry seed in the air dry fruit was, however, made over 3 seasons with samples from the 31 best bearers in the original plantation of 123 seedlings at Zomba and the results are tabulated in Table 4. It will be observed that the variability is very much less than it is for yield, the extreme range being from 39.2 to 46.5 per cent., and it therefore seemed likely that this character would be of minor importance in selection compared to yield. There was some seasonal variation in percentage of seed in the fruit but there were marked positive correlations between the values for the different seasons (Table 4), all of which are significant at less than the 1 per cent. level, thus indicating that individual trees appear to be fairly constant in respect of this character over several seasons.

TABLE IV. *Percentage of air-dry seed in air-dry fruit, 31 bearers at Zomba*

Season	Mean	Standard Deviation	Coeff. of variability %	Range	Correlation Coefficients		
						Value	t
1940(x)	43.15	1.886	4.37	39.2–46.3	R. xy	+0.8234	7.814
1942(y)	42.80	2.069	4.83	39.7–46.5	Rx. z	+0.4920	3.717
1943(z)	43.18	1.939	4.49	39.8–46.3	Ry. z	+0.5801	4.821
All ...	43.04	1.691	3.93	40.1–45.8	—	—	—

Habit and growth

12. WIT (1939) reported the occurrence of two distinct types of tree in Java. One of these (type A), is similar in habit to the Kapok tree (*Eriodendron anfractuosum*), being tall, straight and slender, with regular whorls of, usually five, primary branches forming tiers one above the other at relatively long intervals on the main trunk. The other (type B), usually lacks a main trunk owing to the disappearance of the main axis after formation of the first or second (sometimes third) whorl of primary branches, the latter then growing higher than the short trunk to make a dense bushy crown. These two types occur in Nyasaland but whereas WIT stated that there was a whole range of intermediate forms this is not strictly so in Nyasaland. The essential difference between the two types is the persistence or disappearance of the main trunk. The typical A-type tree described by WIT as resembling the Kapok tree is one which rapidly increases in height and keeps its whorls of primaries as distinct and separate tiers because they are widely spaced on the trunk and because secondaries arise at considerable intervals on the primaries. Such trees are undesirable as they are always poor, or at best

moderate, yielders on account of the fact that they make a great deal of wood but little of it is fruiting wood. In the typical B-type tree the primaries produce numerous secondaries at short intervals and a low, dense, bushy, usually drooping, tree results. They have much more fruiting wood than the A-type just described, begin to bear earlier and give heavier crops. Although there are certain trees which must be classed as intermediate in form, the majority of those which at first sight appear so are really type A since the main trunk persists and the only difference between them and the A-type already described is that the primary whorls are fewer and/or closer together while secondaries arise more frequently, giving the tree a denser appearance and resulting in the production of more fruiting wood. Generally speaking, given similar conditions of soil, &c., the A-types are more vigorous in growth and less precocious in fruiting than the B-types and in some of the latter lack of vigour results in their reaching peak production relatively early in life or in a tendency to biennial bearing.

Experimental Methods

13. The usual statistical procedures and experimental designs have been adopted, the majority of field trials being on the randomised block plan. Certain local difficulties which have been encountered may be briefly mentioned. In experiments with fruit trees under temperate conditions death of, or damage to, trees is relatively rare ; single tree plots can be used for preliminary rootstock and variety trials and the complication of having trees of more than one age class is not usually introduced. Tung trees in Nyasaland are subject to greater hazards. Baboons and antelopes sometimes damage or kill them, white ants and other insect pests may damage young scions in the early stages of growth, and root diseases, particularly that due to *Armillaria melia*, have killed a number of trees. Sub-plots therefore consist usually of not less than three trees and where practicable a uniformity trial before applying treatments is desirable in order that variation due to trees of different ages may be eliminated by use of the analysis of covariance. Where the latter is not practicable the mean value from the surviving trees has been used for plots in which a tree has died. The best size and shape of plot has not yet been determined. In some of the earlier experiments, before much was known about the different clones, vigorous A-type, and intermediate or dwarf, B-type, clones were included in the same trial, but this has been discontinued as it is unsatisfactory on account of the differential competitive effect which occurs unless double guard rows are placed between clone plots—a procedure which is impracticable owing to its high land requirement.

14. Yields have been recorded as lbs. of air dry, hulled seed per tree. When the fruit on a tree is ripe it falls over a period of several days to several weeks, splitting into its one-seeded sections (usually three) as it does so. It is impracticable to harvest, dry, hull and weigh the entire crop of seed from some thousands of trees separately, and therefore the fruit is weighed to the nearest lb. as gathered in the field and a sample is taken from which is determined the percentage of dry seed in the fruit as gathered.

Sampling investigations were carried out on selected seedling trees in order to determine what size of sample was required to characterise a tree with a degree of accuracy such that the error in the yield record would seldom exceed 2 lbs., rarely exceed 3 lbs. and never exceed 4 lbs. of dry seed. This requires that the error should not exceed 0.04M when P=0.02 and gives the data from a large number of small samples from different trees the requisite size of sample can be calculated from the following expression derived from the constants of the normal curve:

$$t = \frac{X - M}{s/\sqrt{n}} \quad \text{or,} \quad n = \frac{t^2 s^2}{(X-M).^2}$$

where M= the population mean, s= the standard deviation, X=the estimate of M from the sample, n= the number of observations, and t= the appropriate value for the required level of probability obtained from Fisher's table of t. With selected seedling trees it was found that a sample of 150 fruit sections (approximately 50 fruit) was adequate to achieve the required standard of accuracy. Subsequent sampling investigations with buddings showed that the same size of sample was ample with all but one clone, which required samples of 200 sections, and also that a random sample of 200 sections drawn from the mixed crop of a plot of three trees of the same clone was sufficient to give a plot yield to the level of accuracy required. The sample of 200 sections has therefore been adopted as a standard.

15. Comparisons of growth and vigour have usually been based upon measurements of girth at 3 ins. above the union. The spread of the branches has also been measured in some cases but is a less satisfactory measurement of vigour.

Selection of Desirable, High-Yielding Mother Trees

16. The first step towards improvement was to discover the best trees in existing seedling plantations and this has been attempted by examining fields tree by tree, numbering individuals which appeared to be carrying a heavy crop, and recording their yields for several years. As it has not been possible to determine the oil content of seed from different trees this, and other, fruit characters (such as the percentage of kernel in the seed), have not been taken into consideration and selection has been based pre-eminently on the yield of dry seed.

17. Notes have been made on the habit of growth and branching of all selected trees and on their vigour. With regard to the latter, actual measurements are of little value for comparative purposes as the trees grow on many estates under widely different conditions of soil and cultivation, and they have therefore merely been classified, after a comparison with surrounding trees, as strong, medium or weak. It has not yet been possible to select trees of any particular habit as being especially desirable as our records so far are inadequate to indicate any correlation between a given branching habit and yield *over a long period.* Furthermore, the best type of tree to plant may depend upon the system of cultivation to be adopted. For example, a low, dense, bushy type of tree with branches drooping to the ground may be desirable on estates where tung is grown as a sole crop and field work is

done by hand labour, because the shade from such a tree minimises weed growth. On the other hand, where intercropping with annuals, such as soya beans, is practised, and where cultivation is done mechanically, a tree which branches fairly high and makes a dense cone shaped head well above the ground is desirable as it permits the easy passage of tractors and implements without interference by the branches. High yielding trees of a number of types have therefore been selected and re-selection, partly on the basis of habit, may be possible later when the performance of different types has been studied over a period of years.

18. Since yield per acre is the main consideration it seemed desirable to take into account the size of the tree and its production per unit area of ground occupied as obviously a large tree giving, say, 40 lbs. of dry seed, would be less valuable than one giving 30 lbs. but occupying only half the area of the former. Some information on this point was obtained by considering the yields over 6 years and spread of the branches of the 31 best trees (all of the A-type) in the oldest Zomba plantation and calculating the yield per 100 sq. ft. of ground occupied. It was found that the biggest trees tended to be the heaviest bearers, there being a positive correlation ($r = +0.4696$) between yield and spread which was significant with p less than 0.01. But it was also evident that, in general, the heaviest bearers had a high yield per unit area of ground occupied, only 2 of the 31 trees being noticeably exceptional in this respect. The correlation between total yield and yield per 100 sq. ft. of ground occupied, at $r = +0.6077$, was significant with p less than 0.01. It must also be remembered that the size of the mother tree or its yield per unit area will not necessarily be closely reproduced in its budded progeny since these characters may be markedly influenced by environmental conditions. Furthermore, the B-type trees are generally smaller and fruit more densely than the A-types but it is not yet possible to decide which is the better of the two types and some of the former, although fruiting densely, are too weak in growth, when budded, to be of much permanent value. Bearing these facts in mind it was decided that the calculation of yield per unit area occupied for each selected tree would be of little help and that in making provisional selections it would be fairly easy to pick out and discard exceptionally large trees which owe their high yield mainly to their size and do not fruit densely.

19. Attempts were made to compare the yields of selected trees growing under varying conditions on a number of estates on the basis of the ratio of the yield of the selected tree to the average yield of the field in which it was grown, the latter being estimated from random sample plots. This failed because owing to wide variation in soil fertility and cultivation within fields, and to variation in the number of predominantly male trees in the plots, the sample plots did not give a reasonable estimate of average yield unless they were so large or numerous as to be impracticable.

20. The work of selection was begun on a small scale in 1940 when only a very small proportion of the total acreage had reached the fruiting stage. It would have been more satisfactory if it had been possible to begin selecting from a large acreage in full bearing but the need for finding good trees from

which budwood could be taken for new plantings, or for converting predominantly male trees in existing plantations, was urgent. Consequently, in this early stage a relatively large number of selections was made from a small total population, and often on the basis of inadequate yield records, with the result that a number of the earlier clones were not of a really high standard. Since that time the work has been expanded from year to year and so far plantations totalling just over 52,000 trees have been examined and 749 provisional selections made.

21. Certain other difficulties have been encountered. Working with immature plantations (probably none of the trees in Nyasaland has yet reached *full* bearing) has undoubtedly resulted in some tendency to select precocious bearers and it is probable that some of the heaviest bearers in these young plantations will be surpassed in future years by slower maturing trees. It will be necessary to continue yield recording, and annually to examine the fields for new selections, over a period of some years. Some selected trees have not borne out their early promise, either because they have shown considerable seasonal yield variation, or because, as with certain B-types, they have quickly reached peak production; others have probably failed to maintain their early high yields on account of a lack of adequate cultivation and manuring which is all too common on estates.

22. From the above paragraphs it will be seen that in the initial selection of mother trees the yield of dry seed has been almost the sole criterion. Since this most important character may be influenced by a number of factors, chief amongst which are environmental conditions, it is evident that a final selection can only be based on the performance of the budded progenies in properly replicated clone trials over a period of years and that other characters, such as oil content of seeds, habit and vigour of growth, &c., will be better taken into consideration in this second stage. For the same reasons, particularly because they grow under varying conditions of soil and cultivation, it is difficult to present yield figures for the mother trees which are of much value, and the main evidence of progress must come from the performance of the buddings derived from them, which is described later. Some indication of yields obtained and types of tree selected may however be obtained from the figures of Table 5, which shows the yields of nine trees from which yield records are available over a period of years and which, with the exception of ZN4, are all amongst the more promising selections. It is of interest to compare these yields with the average yields of seedling plantations given in Tables 1 and 3. The first four trees are good A-types which are fairly steady bearers. The next three are also good A-types but show marked seasonal variation in yield. With the tree ZC2A this has taken the form of biennial bearing owing to the severe reduction in crop caused by hail damage in the 8th year, but the same does not apply to E486 and E378. The last two trees in the table are B-types and their lower yields are not comparable with the other trees as they are much smaller than the A-types. A tree such as Z04, of intermediate vigour, may be valuable although its yield is lower than the first six because its buddings could be planted at a greater density per acre. The tree ZN4 is an example of a weak growing but precocious B-type tree which reaches peak production early and then declines.

TABLE V. *Yields, lbs. air-dried hulled seed*

Tree No.	Age—years										Total Yield 4th-10th Year
	4	5	6	7	8	9	10	11	12	13	
ZM13	17.7	35.7	45.4	51.2	61.3	53.6	76.8	84.2	22.8*	117.8	341.7
E379	16.4	37.6	44.6	51.0	41.4	77.3	42.6	92.0	—	—	310.9
E380	22.1	36.3	45.2	54.7	48.6	57.0	41.5	82.1	—	—	305.4
ZV17	25.2	21.8	30.2	42.5	68.4	46.3	55.6	—	—	—	290.0
ZC2A	17.3	52.8	54.0	50.5	34.2*	106.6	19.1	125.2	33.4	—	334.5
E486	14.1	18.8	18.9	73.2	18.6	55.0	19.8	—	—	—	218.4
E378	3.9	14.0	27.2	32.3	29.2	56.0	28.9	60.0	26.8	—	191.5
ZO4	16.4	17.3	32.0	54.0	23.8	43.3*	23.9	71.0	47.9	—	210.7
ZN4	26.7	26.2	43.6	15.3	25.3	6.7*	27.3	6.5	12.1	—	171.1

*Denotes loss of crop due to hail.

II.—PROPAGATION OF SELECTED TREES AS BUDDINGS

23. The difficulties and inaccuracies attending the selection of mother trees from seedling plantations makes it necessary to base final selection on the performance of the budded progenies and desirable to test a fairly large number of clones. To date, 100 of the selected mother trees have been propagated in clone trials but many of these are either not yet in bearing or have only borne for 2 or 3 seasons and the results herein reported are confined to 15 clones which have been in bearing for some years. In all the trials described below, unless otherwise stated, budding has been done in the nursery by the modified Forkert method on seedling stocks aged 16 to 18 months from the time of planting the seed. After budding the stock has been cut back at 4 inches above the top of the bud patch, and the plant transplanted to the field as a " budded stump " with the main axial root pruned to 18 inches and the side roots to 6 to 9 inches, the scion bud being dormant at the time of transplanting.

Buddings versus seedlings

24. Although it was fairly evident that the use of buddings from selected trees would give higher yields than seedlings it was nevertheless desirable to effect a direct comparison between the two types of planting material and this was done in two of the earliest trials to be planted. The first of these was a small experiment established on an estate in November, 1940, which simply compares buddings and unselected seedlings, the budded plots containing two trees of each of 5 clones. The trial has not been a very satisfactory one as yields have been low on account of the poor soil and, in addition, variability has been high owing to lack of uniform cultivation over the experimental area, which was not fully under the control of the experimenter. In 1945 the crop was destroyed by a hailstorm which occurred at the time of fruit setting but in all other years (Table 6) buddings have given a significantly higher yield than seedlings, although only at the 5 per cent. probability level in 3 out of the 5 years. The clone yields are shown in Table 7 from which it will be seen that, on the 4 years' total yield, the clone ZM13 is superior to all others. The low fertility and standard of cultivation has no doubt prevented the buddings from giving the yields of which they are potentially capable.

TABLE VI. *Mean yields per tree, lbs. air-dry hulled seed*

Age :—	2¼	3¼	5¼	6¼	7¼
Buddings ...	3.3	3.1	13.8	8.4	11.6
Seedlings ...	1.5	1.5	6.6	5.6	5.3
Sig. diff.					
P=0.05 ...	1.49	1.33	3.62	2.58	3.19
P=0.01 ...	2.00	1.78	5.20	3.71	4.58

TABLE VII. *Mean yields per tree, lbs. air-dry hulled seed*

Age, years	Clones					Sig. diff.	
	ZM13	ZM8	ZF9	ZN24	ZN10	P=0.05	P=0.01
3¼	4.3	3.4	2.0	3.0	2.6	1.25	1.64
5¼	20.2	14.6	14.7	10.0	9.4	7.54	9.90
6¼	13.0	8.8	6.7	5.7	7.8	4.23	5.56
7¼	17.2	10.3	9.8	13.8	7.1	9.83	12.92
Mean totals, 4 years ...	54.6	37.1	33.2	32.5	26.9	7.54	9.92

25. In a second trial, planted at the experimental station in December, 1940, the following kinds of planting material are compared:

(*a*) " Unselected seedlings ", raised from ordinary bulk seed.

(*b*) " Selected seedlings ", raised from open pollinated seed taken from 4 good yielding seedlings.

(*c*) Buddings from the same four mother trees on *A. montana* seedling stocks.

(*d*) Buddings from the same four mother trees on *A. fordii* seedling stocks.

26. The mean yields per tree for the different types of planting material over the six seasons when they were aged from 3¼ to 8¼ years at harvesting time are shown in Table 8. It will be seen that the buddings on the *montana* rootstock have given significantly higher yields than all other treatments (P=0.01) in each and every year except in 1944 when there was no significant difference between buddings on the two kinds of stock. On the mean total yields for the six years the buddings on *montana* stock are significantly better than all other treatments, having given approximately double the yield of selected seedlings and more than double the yield of unselected seedlings. Buddings on the *fordii* stock are significantly better than either type of seedling on mean total yields (P=0.01) and also in 1944 (P=0.01) 1946 (P=0.05) and 1948 (P=0.01) and they have always been significantly better than the unselected seedlings. On the other hand, there is no significant difference in yield between the two types of seedling. Table 9 shows the mean girth at 3 inches above the union, or above the single shoot allowed to develop from the seedling stumps. The girth of both types of seedling has been significantly greater than that of either type of budding in all seasons, and buddings on the *montana* stock have been significantly more vigorous than those on *fordii* stock in all seasons after the first. That the difference in vigour between buddings and seedlings is due mainly to the reduction in vigour due to budding,

rather than to the presence of a proportion of predominantly male trees in the seedling plots, is shown by the fact that the mean girth figures for bearers only in the seedling plots at 7½ years old are 28.8 inches for selected seedlings and 26.2 inches for unselected seedlings, both of which are significantly greater than the figure for buddings on *montana* stock with P=0.01. Thus, the girth of buddings on *montana* stock at 7½ years old is only 82.3 per cent. of that of selected seedling bearers and 85.7 per cent. of that of unselected seedling bearers. Since there is a marked positive correlation between vigour, as represented by measurements of girth and spread, and yield (*see* paragraphs 18 and 42) this reduction in vigour due to budding no doubt partly accounts for the fact that budded clones in general have not given, age for age, yields as high as their seedling mother trees. The dwarfing effect of the *fordii* stock is not unexpected in view of the fact this species is invariably less vigorous than *A. montana*.

TABLE VIII. *Mean Yields per tree, lbs. air-dry hulled seed*

Years	Age years	Buddings		Seedlings		Sig. diff.	
		Montana stock	Fordii stock	Selceted	Unselected	P=0.05	P=0.01
1944	3¼ ...	1.8	1.7	0.9	0.7	0.36	0.50
1945	4¼ ...	6.7	3.7	3.1	2.3	1.41	1.95
1946	5¼ ...	9.3	6.2	4.6	4.4	1.78	2.46
1947	6¼	14.7	8.0	7.4	6.3	3.22	4.45
1948	7¼ ...	21.3	14.0	11.2	9.6	3.66	5.06
1949	8¼ ...	28.4	19.5	15.8	12.2	5.58	7.72
Mean total yield per tree 1944-1949 ...		82.2	53.2	42.9	35.5	5.54	7.67

TABLE IX. *Mean girth per tree at 3 inches above union, inches*

Age Years	Buddings		Seedlings		Sig. Diff.	
	Montana stock	Fordii stock	Selected	Unselected	P=0.05	P=0.01
1½ ...	4.9	4.5	6.3	6.2	0.65	0.91
2½ ...	8.9	7.5	10.5	10.0	0.77	1.07
3½ ...	11.6	9.5	14.0	13.7	1.10	1.53
4½ ...	15.0	12.2	17.8	16.8	1.67	2.31
5½ ...	18.2	15.3	21.6	20.9	1.27	1.76
6½ ...	21.4	18.2	25.3	24.7	1.33	1.84
7½ ...	23.3	20.2	28.3	27.2	1.47	2.03

27. Table 10 gives the mean total yields of the budded and seedling progenies of the different mother trees for the six seasons. Of the buddings on the *montana* stock, the clone, ZM13 is significantly better than all others and ZF9 has given a significantly lower yield than any of the others. From the annual yields shown in Table 11 it will be seen that ZM13 has usually given the highest yields and ZF9 has always been the poorest clone. On the *fordii* stock there is less variation between clones, the only significant difference being between clones ZH14 and ZM8. It will be noted that all clones except ZF9 have given significantly better yields on the *montana* stock than on the *fordii* (P=0.01). The marked superiority of the seedling progeny of ZM8 over the other selected seedling families is due to the small proportion

of predominantly male trees occurring fortuitously in the plots of this progeny. All clones on the *montana* stock have given significantly better yields than the seedling derived from the same mother tree and all clones, except ZF9, are significantly better than the seedlings of *any* mother tree. Similarly, the buddings on the *fordii* stock, except for clone ZM8, are better than the corresponding seedling families.

28. This trial has thus clearly shown the superiority of buddings over either selected or unselected seedlings. The use of *A. fordii* as a root stock has nothing to recommend it since it has a marked dwarfing effect, and gives lower yields, as compared with the *montana* stock.

TABLE X. *Mean total yields per tree for six seasons, lbs. air-dry hulled seed*

Treatment	Clones				Sig. diff.	
	ZM8	ZM13	ZH14	ZF9	P=0.05	P=0.01
Montana stock ...	85.1	98.0	86.5	58.8	—	—
Fordii stock ...	47.3	52.9	60.2	52.4	7.26	9.70
Selected seedlings	66.6	41.0	31.8	32.5	—	—

TABLE XI. *Mean yields per tree, lbs. air-dry hulled seed (Buddings on montana stock only)*

Age—years	Clones				Sig. diff.	
	ZM8	ZM13	ZH14	ZF9	P=0.05	P=0.01
3¼ ...	1.7	1.9	2.5	1.2	0.55	0.77
4¼ ...	6.1	9.3	6.1	5.4	1.86	2.44
5¼ ...	9.8	11.2	9.8	6.5	1.61	2.11
6¼ ...	14.8	16.9	14.7	11.9	4.01	5.27
7¼ ...	23.6	26.9	20.6	13.9	4.92	6.47
8¼ ...	29.1	31.8	32.8	19.8	5.23	6.87

Clone trials ; variation in yield, vigour and habit between clones

29. Despite the fact some degree of variation within a clone must necessarily be introduced by the use of seedling rootstocks, there is some evidence to suggest that the rootstock influence is less than that found with temperate fruit trees, such as the apple, and certain characteristics of the mother trees are reproduced with considerable uniformity in all the buddings derived from them. As a result, the buddings from A-type mother trees are invariably A type, while B-type mother trees give rise exclusively to B-type buddings. Moreover, the differences between the two types are to some extent accentuated by budding. The A-type clones are less vigorous than seedlings, but appreciably more so than the B-type clones. Budding does not appear markedly to increase the precocity of fruiting with A-types and, in fact, yields in the early years tend to be somewhat below those give by the mother trees,—a fact which is discussed later. Reduction in vigour by budding is marked, particularly in clones derived from B-type mother trees which are weak, or slightly less than medium, in vigour: such clones are very weak, or even dwarf. Precocious fruiting is a well marked characteristic of all B-type clones and is particularly noticeable in the weakest clones which often fruit one year after budding.

30. All the clones in the two trials already described are of A-type, except for ZF9, which is an intermediate, but the facts noted above are illustrated from a third experiment planted at the station in December, 1940. The main treatments in this trial were intercropping with various annuals which are mentioned later, but five clones were compared in sub-plots. The yields for these clones under all treatments and also for the best treatment (intercropping with soya beans) are shown in Table 12 There are two A-type clones, ZN24 and ZM8, two B-type clones, 14 and 10, and one rather unsatisfactory intermediate, ZF9. The figures for all main treatments and those for the soya plots alone, show that in all seasons and on mean total yields the B-type clones 14 and 10 have given significantly higher yields than all others, (P=0.01), clone 10 being better than 14 when all plots are considered but not in the soya plots only. The intermediate clone ZF9 has proved inferior to all others (P=0.01) as it did in the trial previously described. There are no seedlings in this trial but there are 199 of the same age planted immediately adjacent to the experimental area on what appears to be precisely similar soil and it is of interest to note that the average yields per tree from these seedlings for the five years 1944–1948 have been 0.9, 2.2, 3.6, 6.0 and 8.5 lbs. of air-dry hulled seed, and thus very much less than the buddings. Also in the same field there are 20 trees of one of the weakest and most precocious B-type clones, ZN4, which are one year younger than the trees in the experiment. The mean yields per tree from these 20 trees are shown in the last column of Table 12 and it will be seen that they started off with an even higher yield than clones 14 and 10 but have only increased slightly since.

TABLE XII. *Mean yields, lbs. air-dry hulled seed per tree*

Season	Age years	Clones					Sig. Diff.		Clone
		ZN24	ZM8	ZF9	14	10	P=0.05	P=0.01	ZN4
	All Plots								
1943 ...	2	0.7	0.5	0.6	2.1	2.2	0.31	0.41	3.3
1944 ...	3	1.6	1.6	2.1	5.0	4.0	0.61	0.80	3.9
1945 ...	4	6.3	5.0	5.1	10.0	9.2	1.39	1.82	4.5
1946 ...	5	10.1	9.5	7.8	16.4	19.8	2.00	2.63	5.3
1947 ...	6	10.4	12.2	9.2	17.7	20.9	1.76	2.31	4.8
1948 ...	7	13.9	15.6	11.2	24.6	25.7	2.31	3.04	8.3
1949 ...	8	19.8	22.1	12.7	32.6	36.4	3.51	4.61	—
Mean total yield 1944–1949 ...		62.1	66.0	48.1	106.2	115.9	3.62	4.75	—
	Soya Plots only								
1943 ...	2	1.0	0.4	0.8	2.4	3.1	—	—	—
1944 ...	3	3.4	2.2	3.6	7.7	7.6	—	—	—
1945 ...	4	9.1	6.6	7.6	13.9	13.3	2.78	3.65	—
1946 ...	5	14.6	10.7	11.2	23.5	27.6	2.83	3.72	—
1947 ...	6	13.9	15.2	12.0	21.3	22.7	3.50	4.63	—
1948 ...	7	18.2	16.6	12.8	27.9	28.5	4.63	6.08	—
1949 ...	8	24.5	24.5	16.9	31.6	35.1	7.02	9.23	—
Mean total yield 1944-1949 ...		83.7	75.8	64.1	125.8	134.8	7.23	9.50	—

TABLE XIII. *Mean girth at 3 inches above union (all plots) at 7½ years old* (1948)

ZN24	ZM8	ZF9	14	10	SIG. DIFFERENCE	
					P=0.05	P=0.01
25.3	25.4	20.1	20.1	22.5	1.20	1.58

TABLE XIV. *Mean height to lowest branch, inches*

ZN24	ZM8	ZF9	14	10	SIG. DIFFERENCE	
					P=0.05	P=0.01
33.4	30.4	24.5	20.6	22.0	4.32	5.68

31. The girth measurements at 7½ years old, given in Table 13, show that the two A-clones, ZN24 and ZM8, are significantly bigger than all others (p=0.01) and that clone 10 is bigger than clone 14 and ZF9 (p=0.01). The difference in size and habit of the trees is very evident at a glance in the field. The mean girth for the dwarf clone, ZN4, measured when the trees were 7¼ years old (February, 1949) was only 13.5 inches. The mean height to the lowest primary branch (Table 14) is significantly greater in the two A-clones, ZM8 and ZN24, than it is in the other three clones (p=0.01) between which there is no significant difference.

32. Similar results are being obtained from other, more recent experiments from which records are not available over so long a period. Thus, in Table 15 are given the yields over three years and the girth measurements at 5½ years of three A-type clones, M8, B741 and B742, and two weak B-type clones, 4 and 9. Owing to the weakness of the B-clones their yields are not significantly higher than the A-clones but the girth measurements of both are significantly lower than the A-clones at the 1 per cent. level. The figures from another clone trial, given in Table 16, again show the quick cropping and superior yields, over the first three years, of two B-clones, 14 and Z04, as compared with the A-clones ZM13, ZN24 and B741. In the fourth season there was no significant difference between clones, possibly because the heavier cropping, weaker B-types were more seriously affected by the drought experienced in that year. This trial contains a very promising A-clone, ZC2A, which also comes into bearing early and gives high yields. On the mean total yields for the four seasons the two B-clones are better than all the A-clones except ZC2A.

TABLE XV

Age years		CLONES					SIG. DIFF.	
		ZM8	B741	B742	4	9	P=0.05	P=0.01
3	Mean yield, lb. dry seed per tree	2.5	1.7	3.5	2.2	3.9	0.80	1.05
4		4.5	6.0	5.7	5.9	5.8	2.01	2.65
5		14.1	15.9	19.3	14.0	11.7	6.20	8.15
5½	Mean girth, inches ...	19.0	17.8	18.2	14.7	12.9	2.07	2.72

TABLE XVI. *Mean yields per tree, lbs. air-dry hulled seed*

Year	Age	Clones						Sig. Diff.	
		ZM13	ZN24	ZC2A	B741	14	Z04	P=0.05	P=0.01
1946	3¼	4.9	4.4	11.3	7.7	16.6	12.0	2.74	3.79
1947	4¼	16.7	13.7	22.2	16.6	24.1	20.5	4.94	6.84
1948	5¼	22.9	17.5	32.2	21.3	34.3	30.1	5.30	7.33
1949	6¼	26.7	22.9	31.1	19.0	24.1	25.7	No. sig.	diff.
Mean total yield 4 seasons ...		71.3	58.5	96.8	61.6	99.1	98.3	13.54	17.80

33. The results obtained from the clones described above, which, as far as can be seen at this stage, appear to be a fairly representative sample of 100 under trial, thus indicate that there are consistent and well marked differences between the A and-B types. The more vigorous, and less precocious, A-types are all derived from mother trees which have given high yields from the 6th to 8th year onwards, and it is expected that the clone yields will continue to increase for some years. The strongest of the B-clones, such as 10, may also give further increases in yield for several years, but the weaker clones, such as 4 and 9, are expected to reach an early peak, while it is clear that the dwarf ZN4 can never give high yields per tree. The mother tree of this last is only slightly less than medium in vigour and has given much higher yields, age for age, than its buddings (c.f. Tables 5 and 12). The combination of reduction in vigour due to budding and very precocious fruiting results in the trees of this clone being permanently dwarfed so that the only possibility of their satisfactory use would be to plant them at a high density per acre. They have, however, another disadvantage in that many trees tend to develop biennial bearing or may even over crop to an extent which causes die-back of twigs. These undesirable characteristics accompanying lack of vigour also occur to a less extent in other weak B clones. Soil fertility naturally has a marked effect and in general it may be said that although reasonably good conditions of soil and cultivation are necessary for good yields from any type of plantation, seedlings will stand poorer conditions than buddings and A type buddings are less sensitive than B-type, the latter making but poor growth and giving low yields unless conditions are good.

34. It is not yet possible to say which of the two types of clone will prove the more useful. It will probably be found advantageous to use a mixture of both types, planting the A trees, at a relatively wide spacing and interplanting with the quicker cropping and smaller B-types which can be cut out in due course as the former mature. Some of the stronger B-types, such as clone 10, are likely to be satisfactory as permanent trees at a suitable spacing.

35. It is also hardly possible to make final recommendations regarding the best individual clones to plant. Most of the clones mentioned above resulted from early selections when the survey of seedling plantations was limited. As far as can be judged at present they include two really good A, clones, ZM13 and ZC2A, and three good B-types—10, 14, and Z04. The remainder seem to be definitely inferior to these five in performance but it is evident that a really discriminating selection can only be made when

yields over a longer period are available. The records from some of the more recently selected mother trees together with the first one or two crops from their buddings suggest that better results will be obtained from the newer clones than from most of the old ones.

36. It has been observed that, in general, the average yields given by budded clones are appreciably less than the yields of the respective mother trees at the same age. One probable cause of this is the reduction in vigour due to budding which has already been mentioned. The effect of variable seedling rootstocks might also be expected to reduce clone yields as compared with mother trees. Clone yields, too, are at a disadvantage compared with mother tree yields because they are the average yields of a number of trees spread over an area in which there must necessarily be some soil variation and all the trees suffer some degree of competition from neighbours which must be relatively good bearers and therefore make a relatively heavy drain on soil nutrients. A lower yield from a few members of the clone, due perhaps to a patch of poor soil or slight damage, naturally reduces the average. Mother tree yields, on the other hand, are from single trees which are unlikely to be on particularly poor soil or to have neighbouring trees which are all high yielders. A combination of these causes may well be sufficient to account for the differences observed, but the differences are usually big enough to make it worth while investigating the matter further Such an investigation, however, must await the provision of clonal rootstocks before it can be really effective.

Variation between clones in certain fruit characters

37. As already mentioned, fruit characters, such as the percentage of seed and kernel in the fruit, &c., were not taken into consideration in the selection of mother trees because facilities and staff were not available to determine the oil content of seeds and kernels. In 1945, however, it was possible to have seeds analysed for oil content and a preliminary investigation was therefore made of the differences between clones in respect of certain fruit characters. Two series of clones were studied, the first of which consisted of samples from 5 trees of each of the 5 clones of the trial described in paragraph 30. A second series of samples was taken from three of the four clones of the experiment described in paragraph 25, samples being taken from 5 trees of each of the 3 clones on both *montana* and *fordii* stocks.

38. The results are summarised in Tables 17 and 18. There are significant differences between clones in mean seed weight, but as there was no correlation between seed weight and yield, percentage kernel in the seed or oil content, it appears that clones which have particularly heavy or light seeds would not have any practical advantages. Seed weight on the *montana* stock (Table 18) is significantly higher than on the *fordii*, but there are no significant differences between stocks for any of the other characters. As regards the percentage of air-dry seed in the air-dry fruit, the only significant difference occurs in the first series (Table 17) were clone ZN24 has a lower percentage than any other clone. There is no significant correlation between this character and yield or percentage of kernel in the seed and therefore its only practical importance is that with some clones a greater weight of fruit must be transported to give the same yield of seed. If clone ZN24 is disregarded, the variation between the other clones is much smaller, and as

the fruit is hulled on estates before sending the seed to the oil extracting factory, the variation in this character is not likely to be of any real importance. Significant differences between clones are also apparent in respect of the percentage of air-dry kernel in the air-dry seed, but the range of variation is small being from 60.41 to 65.00 per cent.

TABLE XVII

	Clones					Sig. Diff.	
	ZM8	ZN24	ZF9	14	10	P=0.05	P=0.01
Mean seed wt. gm. ...	3.400	2.756	2.726	2.620	3.005	.103	.140
% air-dry seed in air dry fruit	42.3	34.6	42.0	41.8	42.7	4.36	5.94
% air dry kernel in air dry seed ...	62.59	60.88	64.25	61.32	65.00	1.34	1.83
% oil in air dry seed	38.05	36.39	40.80	37.73	40.92	1.40	1.90
% oil in oven dry seed	40.43	38.75	42.89	40.25	42.82	1.30	1.77
% moisture in air dry seed	5.85	6.10	4.87	6.27	4.44	—	—
% oil in oven dry kernel	62.47	61.73	64.87	63.93	64.19	—	—

TABLE XVIII

	Stock	Clones			Stock Means	Sig. differences			
						Clones		Stocks	
		ZM8	ZM13	ZH14		P=0.05	P=0.01	P=0.05	P=0.01
Mean seed wt. gm...	M ...	3.468	3.145	3.380	3.331	.142	.193	.083	.111
	F ...	3.361	2.943	3.162	3.155	—	—	—	—
	Mean	3.414	3.044	3.271	—	.101	.137	—	—
% air dry seed in air-dry fruit	M ...	40.4	44.4	43.1	42.7	No significant differences			
	F ...	39.4	42.7	45.4	42.5				
	Mean	39.9	43.5	44.2	—				
% air-dry kernel in air-dry seed	M ...	63.50	63.20	63.94	63.54	.875	1.185	N.	S. D.
	F ...	64.03	62.44	63.21	63.23	—	—	—	—
	Mean	63.77	62.82	63.57	—	.619	.838	—	—
% oil in air-dry seed	M ...	39.57	39.80	41.27	40.21	1.240	1.681	N.	S. D.
	F ...	39.59	39.60	40.98	40.06	—	—	—	—
	Mean	39.58	39.70	41.12	—	.876	1.190	—	—
% oil in oven dry seed	M ...	41.60	41.98	42.94	42.17	.930	1.260	N.	S. D.
	F ...	41.49	41.40	42.91	41.93	—	—	—	—
	Mean	41.54	41.69	42.93	—	.656	.889	—	—
% moisture in air-dry seed ...	Mean	4.73	4.76	4.21	—	—	—	—	—
% oil in oven dry kernel ...	Mean	63.31	64.33	65.52	—	—	—	—	—

39. The oil content of the air-dry seed ranges from 36.39 to 41.27 per cent. and that of the oven dry seed from 38.75 to 42.94 per cent. As differences in moisture content between clones are small the significant differences as regards oil content are the same whether on an air dry or oven dry basis: in the first series clones 10 and ZF9 are better than the other three and in the second series ZH14 is better than the other two. The variation in oil content is again so much less than that in yield of dry seed that the latter is obviously a far more important criterion of selection and the order of merit of clones or mother trees is unlikely to be altered appreciably from that obtained on a dry seed basis if the yields are converted to lb. of oil. The differences between clones in oil content may, nevertheless, be sufficient to be of some economic importance, since the difference between the highest and the lowest is just over 11 per cent. of the lower value. If the trees were giving an average yield of 30 lb. of air dry seed per tree, or 1,680 lb. per acre at the present normal spacing at the experimental station, a maximum difference of 82 lb. of oil per acre might occur and the value of this to the grower would be about £4 at present prices. No definite conclusions, however, can be drawn until a more detailed investigation has been conducted in which the highest yielding clones are compared, and the effects of season and manuring on oil content, &c., are studied.

Variation between clones in flowering and fruit setting

40. Observations have been made on flowering and fruit setting with the object of : (*a*) determining whether there are consistent differences between clones in respect of number of flowers, fruit, and seed per cluster, percentage of female flowers which set fruit, and number of seeds produced per female flower, (*b*) correlating these characters with yield and endeavouring to determine the way in which yield may be affected by them. These investigations have been mainly conducted with the five clones of the trial described in paragraph 26.

TABLE XIX

Character	Year	Clones					Sig. diff.	
		14	10	ZN24	ZM8	ZF9	P=0.05	P=0.01
Number of female flowers per cluster	'44...	12.57	21.30	22.33	13.71	27.27	1.97	2.59
	'45...	12.23	13.31	18.65	13.55	24.05	1.97	2.59
	*Mean ...	12.40	17.31	20.06	13.63	25.66	1.40	1.83
	'48...	12.85	12.20	22.57	15.06	24.09	4.24	5.74
Number of fruit per cluster	'44...	3.27	3.06	3.96	2.15	3.75	0.33	0.45
	'45...	3.25	2.88	3.02	2.33	3.63	0.33	0.45
	*Mean ...	3.26	2.97	3.49	2.24	3.69	0.24	0.32
	'48...	3.68	3.22	2.90	2.02	3.11	0.59	0.79
Percentage of female flowers setting fruit	'44...	26.28	14.13	18.60	15.72	13.73	2.51	3.30
	'45...	26.79	21.66	16.37	17.26	15.02	2.51	3.30
	*Mean ...	26.54	17.89	17.49	16.49	14.37	1.77	2.33
	'48...	28.64	25.86	12.90	13.46	13.04	1.79	2.42
Number of seed per cluster	'44...	9.55	8.88	10.72	5.53	9.69	1.43	1.88
	'45...	9.69	8.17	8.05	5.51	8.35	1.43	1.88
	*Mean ...	9.62	8.52	9.39	5.52	9.02	.90	1.19
	'48...	10.61	9.40	8.21	5.62	9.15	1.77	2.39

* For the two seasons 1944 and 1945.

TABLE XIX—*Continued*

Character	Year	Clones					Sig. diff.	
		14	10	ZN24	ZM8	ZF9	P=0.05	P=0.01
Number of seed per female flower	'44...	.765	.408	.545	.403	.361	.076	.100
	'45...	.795	.603	.436	.414	.361	.076	.100
	*Mean ...	.780	.505	.490	.424	.361	.054	.071
	'48...	.824	.745	.366	.376	.382	.055	.074
Number of seed per fruit	'44...	2.92	2.90	2.71	2.57	2.58	.53	.70
	'45...	2.98	2.84	2.67	2.36	2.30	.53	.70
	*Mean ...	2.95	2.87	2.69	2.46	2.44	.33	.44
	'48...	2.88	2.92	2.83	2.78	2.94	.61	.83
% of male flowers ...	'48...	0.23	0.32	0.83	6.57	4.63	—	—

* For the two seasons 1944 and 1945.

In 1944 and 1945 observations were made on 26 trees of each of the 5 clones and in 1948 on 5 trees of each clone. The results of all these observations are summarised in Table 19. It will be seen that, with the possible exception of clone 10, the values obtained for each clone are fairly consistent, that there are significant differences between clones, and that the seasonal differences within clones are appreciably less than the differences between clones in any season. Thus, for example, the clone ZF9 consistently has more female flowers per inflorescence than any other (P=0.01): clone ZM8 has a smaller number of fruit and seed per cluster than all others in every season (P=0.01); and clone 14 has a higher percentage set and higher number of seed per female flower than all others in every season (P=0.01). If the observations for all clones in both the seasons 1944 and 1945 are considered there is significant negative correlation (r=—.4430) between the number of female flowers per cluster and the percentage setting fruit, but when the clones are considered separately, although the correlation is in all cases negative, it does not reach a significant level except for clone 10 (r=—.3859). This is taken to indicate that as the average number of female flowers per cluster increases there is a tendency for the percentage of female flowers which set fruit to decrease but this probably may not operate below a certain number of female flowers per cluster and is also probably affected by the vigour of the tree. Clones 14 and 10 appear to be markedly more "efficient" than the others as although they have less female flowers per cluster they have a higher percentage set and better filled fruits. There were significant differences between season, the number of female flowers, fruit and seed per cluster being greater in 1944 than in 1945 (P=0.01) but the percentage of female flowers setting and number of seed per female flower being higher in 1945 than in 1944 (P=0.01).

41. The figures for the percentage of male flowers produced by each clone, which are shown in the last line of Table 19, are not of much value as the size of sample is quite inadequate to give precise records in this respect. This is because the relatively small proportion of male flowers is borne partly in mixed inflorescences and partly in purely male inflorescences and the chance presence or absence of one of the latter in a sample of the size used will give widely different results. Very much larger samples would be necessary accurately to characterise a tree in respect of the percentage of male flowers

and the figures given can only be taken to show that clones ZM8 and ZF9 produce appreciably more male flowers than the others.

42. The above observations indicate fairly clearly that, although season has some effect, there are consistent differences between certain clones in the characters studied. The more important matter of the correlation which may exist between these characters and yield cannot be examined from these data because the size of sample used was inadequate to characterise individual trees. Owing to the large number of observations required, the study of possible correlations with yield is a somewhat formidable undertaking and it has not yet been possible to carry it out. Moreover, it is doubtful if it would be worth while in view of the amount of work involved, because there are obviously other factors which must affect yield, such as the size and vigour of the tree, the total number of fruiting points or flower clusters, soil and season. That size of tree has a very big effect is evident from the marked positive correlations obtained between yield and girth at 3 inches above the union, and between yield and spread of the branches, which are shown in Table 20. All these correlation co-efficients are significant at the 1 per cent. level except that for yield and girth for clone ZM8.

TABLE XX—*Correlation Coefficients*

Clones	14	10	ZN24	ZM8	ZF9
Between yield and girth	.6610	.6011	.7955	.3444	.7727
Between yield and spread	.6344	.7925	.7428	.7512	.7089

Pollination in budded plantations

43. It has already been mentioned that, during any one blossom season, bearing trees generally at first produce only female flowers and only open male blossom after this female phase is over, although on some trees there may be some overlapping. It might therefore be expected that some special provision of predominantly male pollinators might be necessary in budded plantations. Some observations on pollination in both seedling and budded plantations have already been published (WEBSTER 1944). Since 1943 records have been made every year at three-day intervals throughout the blossoming season of the number of trees with open male and female flowers on each occasion for each of a number of clones. With almost all the clones studied there is a period during the early part of the blossom season when only female flowers are opened and although all clones later produce some male flowers some of them do so in insufficient amount for full pollination. For example, clone 14 in 1944 opened no male flowers until at least 19 days after flowering had begun, by which time 74 per cent. of the trees had open female flower, while for clone 10 in the same season the corresponding figures were 19 days and 45 per cent. It is therefore necessary to provide pollinators in the shape of selected predominantly male trees which flower early in the season and have a long blossoming period. The proportion of such pollinators which is required has not yet been precisely determined but the evidence suggests that pollen will be adequate if budded plantations (*a*) contain 5 per cent. of such pollinators, and (*b*) are polyclone.

Note on vegetative propagation of rootstocks

44. Small scale experiments have been made with various methods of propagation in order to try to raise trees on their own roots or to produce clonal rootstocks but have so far been largely unsuccessful. Hardwood stem cuttings have been made from wood of different ages and of different lengths and thickness; they have been taken at various times of the year and set in several media, with and without the application of growth promoting substances, but although leafy shoots have been produced and maintained in healthy condition for as long as five months, no rooting has ever occurred. At Amani (E.A.A.R.I., 1946) experiments with hardwood cuttings were similarly unsuccessful, although a very small percentage did produce a few fine roots but rotted before they could be potted up. Both at the Tung Station and at Amani, softwood cuttings all rotted and died without any rooting. Stooling, provided that the young shoots were etiolated and then constricted by one or two turns of wire, was successful in providing rooted shoots, but the method is not really a practicable one for the propagation of selected material on any scale. Layering was less successful as although roots were produced the amount of root was quite inadequate to support the strong growth of stem above it and even when the latter was cut back only a few plants were successfully transplanted. A high percentage of root cuttings of *A. fordii*, either from young or mature trees, successfully rooted and produced plants, but only moderate success has so far been obtained with *A. montana* root cuttings taken from young seedlings and a low percentage of plants from cuttings from mature trees. Recent experiments give hope that conditions will be found which will yield better results. Limited success with root cuttings has been reported from Amani but it is not clear whether the cuttings were taken from old or young trees.

III. Improved Types of Seedling

Open pollinated seedling families

45. Families of seedlings grown from open pollinated seed taken from selected mother trees would not generally be expected to give yields as good as those obtainable from buddings. With the species *Aleurites fordii*, however, it has been found that the open pollinated seedling progenies of a number of selected trees have come remarkably true to the type of the mother tree. Dickey (1942) made a study of the seedling progenies derived from two selected trees, Florida No. 2 and Florida No. 9, comparing seedlings and mother trees in respect of the following five characters:—(*a*) habit of growth, (*b*) type of inflorescence, (*c*) shape and size of fruit, (*d*) time of fruit fall, (*e*) size of crop. He found that 69.2 per cent. of the No. 2 seedlings and 74.8 per cent. of the No. 9 seedlings varied from the parent in only one character, while 56.9 per cent. and 59.4 per cent., respectively, had all characters in common with the parent and were so true to type that it was impossible to distinguish them from budded trees of the same parents. Blackmon (1944), working with the same trees, which were planted in a replicated trial with buddings from the same parents, presents yield records over a period of eight years which show that both seedling families consistently gave higher yields than the corresponding clones. Angelo (1943) made observations on a large number of open pollinated seedling progenies and noted that many of them resembled the female parent so closely that the

latter could often be named on looking at the seedlings without any reference to labels or plans. POTTER (1947) accepts the well established fact that the open pollinated seedling progenies of certain trees are remarkably uniform and true to type but points out that "the majority of seed parents give evidence of a heterozygous genetic constitution by producing exceedingly variable offspring even from controlled selfed seed". He suggests that the uniformity of the seedlings from certain parent trees may be due to the production of fruit parthenocarpically, or to the fact that certain trees are rather homozygous for a number of genes, possibly dominant genes, that determine tree type, and are either self pollinated, or that cross pollination occurs but the genes concerned are largely dominant. He concluded that "critical evidence of the relative merits of the best seedling progenies and of budded clones is lacking", and that more evidence must be awaited before definite recommendations can be made as to whether it is best to plant budded clones or open pollinated seedlings of the so called "progeny tested" trees. Further evidence has since been presented by LAGASSE, POTTER and BLACKMON (1948), who have studied a number of budded trees and seedling progenies originating from the same parent and have shown that the seedlings are consistently more variable in respect of certain fruit characters (per cent. oil in kernel, per cent. kernel in fruit, per cent. oil in fruit, weight of fruit and kernel) than the buddings. They do not present any comparative data for yield or variability in yield.

46. With *Aleurites montana* it seems unlikely that such seedling families could give results comparable with buddings, especially as the former will always contain a proportion of predominantly male trees. Natural self pollination is very much less likely to occur in *A. montana* than in *A. fordii*, as the latter, with rare exceptions, produces male and female flowers in the same inflorescence, (the normal ratio of male to female being about 40 to 1), and dichogamy is unknown. Nevertheless, it is possible that certain selected mother trees might give rise to relatively high yielding open pollinated seedling progenies and it was considered desirable to investigate the matter, particularly as, (*a*) it would be possible to convert the predominantly male trees to bearers by budding on the main branches; and, (*b*) some valuable new selections might be found amongst the bearers in these families. The difficulty about carrying out such an investigation comprehensively is that, as a relatively large number of mother trees and a fair number of seedlings in each family should obviously be used, land and labour requirements would necessarily be high. Consequently, it was thought advisable to collect evidence from some small preliminary experiments before deciding whether to go ahead with a larger investigation.

47. Four illegitimate seedling families were included in the experiment described in paragraph 25 and it has already been shown that each of these gave significantly lower yields than the corresponding budded clone on *montana* stocks, that all gave lower yields than any clone except the inferior clone ZF9, and that the average yields of the selected and unselected seedlings have never differed significantly. A second experiment was planted in December, 1941, which compares unselected seedlings, four open-pollinated seedling progenies from selected mother trees, and clones of buddings from three of the four mother trees. This is only a small randomised block trial with 3 tree plots replicated 8 times giving 24 trees in each seedling family or clone, and

as it is accommodated in the guard rows of a larger trial the blocks are not contiguous. No great precision can therefore be expected. The yields for three seasons and the mean total yields over the same period are shown in Table 21. On the mean total yields all three clones of buddings are better than any of the seedlings, selected or otherwise, except that clone N10 is not significantly superior to seedlings of B740. Seedlings of B740 are better than unselected seedlings, but the three other selected seedling progenies are not. On the annual yields similar results were obtained in 1947 and 1949, but in 1948 there were no significant differences, which is believed to be due to the fact that the hail damage occurring in that season was more severe on the budded than on the seedling plots. If the seedling progeny of B740 be excepted, the two experiments have given the same indications, namely that buddings are better than selected seedlings and the latter do not give significantly higher yields than ordinary unselected seedlings.

TABLE XXI. *Mean yields, lbs. dry seed per tree*

Age Years	Seedlings					Buddings			Sig. diff.	
	US	B742	B740	ZN21	ZN10	B740	ZN21	ZN10	P= 0.05	P= 0.01
5... ...	1.5	2.5	2.9	1.6	2.3	4.9	5.1	3.8	1.92	2.52
6... ...	3.4	3.8	4.4	4.6	3.1	6.2	7.5	5.7	3.87	5.09
7... ...	9.7	12.5	16.1	9.7	11.5	23.6	21.0	17.9	—	—
Mean total 5-7 ...	14.6	18.8	23.4	15.9	16.9	34.7	33.6	27.4	7.11	9.35

48. In a third small trial open pollinated seedlings from eleven mother trees have been compared with buddings of the clone ZM8, there being 18 individuals in each family arranged in 18 randomised blocks each of 12 one-tree plots. Naturally, no precise information can be expected from such a small trial but the results, summarised in Table 22, show some points of interest. All the A-type mother trees have given rise exclusively to A-type seedlings, whereas in the progenies of three of the four B-types there is a majority of B-type trees. The figures for percentage of predominantly male seedlings are based on too small a number of trees to be of much value, but two of the progenies are worth noting. The mother tree ZM6, which is predominantly male and was included as a matter of interest, has produced 17 predominantly male seedlings out of 18. The tree KAR was probably self-pollinated, as it produced a fair crop year after year although isolated from other tung trees, and its seedlings show the lowest percentage of males—22 per cent. When 15 more seedlings of this tree which are growing alongside the experimental area are taken into consideration there are only 5 of the 33, (approximately 15 per cent.) which are predominantly male. The yields of the ZM8 buddings are not significantly inferior to any of the seedling families in either year, but are only significantly better than the seedlings of ZM6 and B737. This clone is not one of the best and has given much lower yields than clones 10 and 14 in other trials. Three of the seedling families, B733, 14 and 10, are outstanding, being significantly better than six of the others in both seasons. The yields of the bearing trees of the 14 and 10 families are particularly good, but both families have a high proportion of males. Unfortunately, this experiment has had to be abandoned owing to a number of deaths from *Armillaria*.

TABLE XXII

Parent tree :—	ZC2A	ZL22	B733	ZM2	ZO23	ZN24	14	10	B737	KAR	ZM6	M8	Sig. diff. .05
Habit of parent tree ...	A	A	B	A	A	A	B	B	A	B	A	A	
Habit of seedlings—													
A	18	18	5	18	18	18	6	8	18	14	18	18	—
B	—	—	13	—	—	—	12	10	—	4	—	—	—
Percentage of male seedlings	56	35	39	24	39	39	61	50	76	22	94	0	—
Mean yield all trees,													
Age 4	2.9	2.9	6.7	2.8	5.6	4.2	6.4	6.5	1.8	5.1	0.7	6.3	3.3
Age 5	6.0	5.1	12.8	5.0	7.8	5.5	9.5	11.8	2.7	9.7	0.7	9.2	5.3
Mean yield, bearers only,													
Age 4	5.8	4.4	9.8	3.6	8.8	6.7	14.5	11.6	5.4	6.0	8.2	—	—
Age 5	13.4	7.6	18.7	6.6	12.0	9.5	22.1	20.3	7.6	12.0	9.1	—	—

49. The results of these three small trials indicate that there is a possibility that the illegitimate seedling progenies of certain mother trees may contain a fair proportion of individuals which come fairly true to the type of the mother tree as regards habit, and that the bearers in such families may give rather good average yields and include some outstanding individuals amongst them. The general indication, however, is that open pollinated seedling progenies will give yields inferior to buddings from the same mother tree. It could therefore hardly pay to plant such seedlings and subsequently to bud the males on the branches; nor would it be worth while planting them for the sake of the outstanding mother trees which might be found amongst the bearers, as there is much greater likelihood of obtaining valuable new mother trees from legitimate seedling families. These are indications only, and to obtain conclusive information it would be necessary to establish a larger trial in which the seedling progenies of a number of the best mother trees were compared with buddings, but the preliminary results suggest that this is one of the least promising lines of improvement and it is concluded that further work with illegitimate seedling progenies is not at present worth while.

Clonal seedlings

50. In 1941 three small isolated plots of buddings were planted with a view to finding out if by crossing between themselves these buddings would produce seed which would give rise to a high yielding stand of trees. Two of the plots were monoclone and one contained a mixture of six clones. A small crop of seed was obtained from all plots in 1944, although since that time one of the monoclone plots, that of clone ZM13, has not set a single fruit. This is explained by the fact that this clone habitually produces more, and earlier, male blossom in its first season than thereafter. Seedlings raised from the 1944 crop were planted out in a trial which included plots of buddings of clone ZM8 for comparison. These seedlings contain an average of 28 per cent. of predominantly male trees, compared with 45 per cent. in ordinary seedling plantations, so far they have only borne their first light crop, on which all three " progenies " yielded less than the buddings of clone ZM8.

Legitimate seedling families

51. Artificial selfing of, or crossing between, high yielding mother trees, or buddings derived from them, was carried out from 1940 to 1943 with the object of raising families of legitimate seedlings. The usual methods employed for this kind of work were found to be quite satisfactory. Cellophane bags were used to enclose the inflorescences and as these bags were rather small it was found necessary to reduce the size of the inflorescence by pruning off some of its branches, so that only four to eight flowers were pollinated in each bag. Unopened female flowers were bagged one to two days before pollinating, care being taken to remove any male flower buds occurring in mixed inflorescences. Male flowers on the pollen parent were also bagged. Freshly opened male flowers were used: usually anthesis had not occurred when they were removed from the tree and they were exposed to the sun in bags until it did so. Pollination was effected by very gently brushing the freshly dehisced anthers against the stigmas, all the female flowers in a bag being pollinated with the same pollen parent. Bags were kept on the female flowers

for 14 days after pollination. The mean percentage of successful pollinations was 34.2; this is higher than the percentage of female flowers setting fruit naturally in other experiments and the higher set is probably due to the reduction in the number of female flowers per cluster which was made before bagging. In all three seasons a number of inflorescences were bagged but left unpollinated, a total of 283 flowers on 12 trees. None of these set any fruit. A satisfactory set of fruit was obtained as a result of self pollination on all the eleven trees on which it was tried, indicating that self fertility is fairly general, which was also observed in Java by WIT (1939). Selfing is not possible on all bearing mother trees as by no means all of them open flowers of both sexes the same time and as the female flowers are produced before the males it is not possible to remove and store pollen for later use. This difficulty can usually be overcome if a number of buddings of the mother trees are available, particularly if there are several plots of buddings growing under different conditions, *e.g.* buddings of a given clone usually flower somewhat earlier in the Southern part of Cholo District than at the Tung Station, as there is a difference of 1,000 feet or more in altitude.

52. A total of 650 of these legitimate seedlings, belonging to 14 families, has been established and the yield records from the first two crops indicate that some very promising individuals are probably present. The percentage of predominantly male trees varies in the different families, from 18.7 per cent. to 42.8 per cent., with a mean of 26.1 per cent. Despite the fact that a B–type tree was used as one of the parents in four of the families there are only 5 B-type seedlings amongst the whole 650, all families with two A-type parents, and two of those with one B-type parent, consisting wholly of A-type trees. This, together with results of the trial reported in para. 48, seems to indicate that the B-type character is recessive. No families with both parents B–type have yet been planted but a large number of selfings and crosses of the best B–types were made at the end of 1949.

53. These legitimate seedling families were mainly produced in the hope that amongst the bearing trees there will be some really outstanding yielders which can later be propagated to form new and superior clones of buddings. It is probable that the number of first class selections from which it is eventually desired to propagate will be quite small, but in order to save time, and also to obtain more accurate information, a few buddings have been made from each of a number of the most promising bearers after recording the first two crops. Thus it will in due course be possible to base a final selection not only on the yield of a single outstanding seedling (which may be affected by soil, &c.) but also on the performance of a small number of buddings derived from it.

Hybrid Seedlings

54. It has long been evident that *Aleurites fordii* gives very much lower yields than *A. montana* under Nyasaland conditions, with the result that planting of the former species ceased some years ago. The *fordii* oil, however, is generally considered to be of slightly better quality than *montana* oil and it was therefore thought worth while raising some hybrids by controlled crossing between good trees of the two species in the optimistic hope that the progeny might combine the high quality of one parent and the high yield of the other. In fact, of the 60 six-year-old hybrids now growing at the

station, 50 have regularly produced staminate flowers only from their third season onwards. The remaining 10 have been monoecious, bearing male flowers in many-flowered loose cymes similar to the *fordii* inflorescences and a small number of purely female inflorescences of the *montana* type containing 12 or less flowers. The percentage set has been poor and fruits are most commonly borne singly, but sometimes in clusters of up to four. Yields have been neglibible as no tree has borne more than a few fruit. In almost all characters, including vigour, the hybrids are intermediate between the two parents, but leaf shape more closely resembles that of *A. fordii* and the corolla colour of the flowers is an even deeper pink than in *fordii*.

55. Hybridisation between the two species was carried out many years ago at the Florida Agricultural Research Station (KILBY, 1948) but all the resulting trees were practically sterile. More recent work along this line has been undertaken by the United States Department of Agriculture, but KILBY (1948) reports that at six years old most of the resulting trees bore only staminate flowers, only one or two being fruitful. STOCKAR (1947) made a number of interspecific crosses between *Aleurites* spp. but reported that at six years old only one of his *montana* × *fordii* hybrids had borne fruit.

IV. CULTURAL AND MANURIAL EXPERIMENTS

56. Up to the present time only a very small beginning has been made with experimentation on the cultivation, intercropping and manuring of tung in Nyasaland as it was essential that priority should be given to the production of improved planting material. It was also necessary for the initiation of cultural and manurial experiments to await the provision of more or less standardised budded plants as it is obviously impossible to conduct such experiments with any reasonable degree of accuracy if the plots consist of variable seedling trees and contain a variable proportion of males and bearers. Such work has further been seriously handicapped because it has hitherto been impossible to obtain chemical analyses of soils, manures, &c.

Inter-cropping and cultivation

57. Results over several seasons are only available from a single field experiment in which inter-cultivation with annuals is practised. This is a trial, begun in December, 1940, which compares inter-cropping during the first four rainy seasons (1940/41 to 1943/44) with: (*a*) soya beans, the whole plants being removed for threshing at harvest time; (*b*) maize, stalks being buried after harvest; (*c*) velvet beans (*Mucuna utilis*) dug in annually as a green manure; (*d*) a cover crop of *Calapogonium mucunoides* which was intended to be permanent but which died out early in the fourth season owing to its failure to set seed and re-sow itself. The inter-crops were grown on ridges 3 feet apart and in the plots under treatments (*a*) to (*c*) these ridges were split at the end of each season to bury crop residues and weed growth. Cultivation of the annuals did not extend to within a six-foot radius of the tung plants in the first season and subsequently it was not done under the spread of the

branches. After the 1943/44 season it was intended to put the whole of the experimental area under a permanent leguminous cover crop but shortage of labour prevented this and consequently since that time the trees have received no cultivation beyond circle weeding under the spread of the branches and slashing or hoeing of grass and weeds between the rows.

58. The results over a period of six years are tabulated in Table 23. In all seasons, except 1949, and also on the combined yields for the six seasons, the plots under soya beans have given the highest yields, being significantly better than all other treatments at the 1 per cent. probability level. The *Calapogonium* plots were significantly inferior to the maize and velvet bean plots in 1945 and to the maize plots in 1947 ($p=0.05$) but not in other seasons. The girth measurements for 1948 show that the trees in the soya bean plots were significantly bigger than all others ($p=0.01$), there being no significant difference between the latter. Girth records taken in earlier seasons showed that trees in the maize plots were significantly bigger than those in the velvet bean and *Calapogonium* plots for the first three seasons, but not subsequently. Accounts were kept of the costs of cultivation and value of the crops (tung, soya and maize) under the various treatments and these showed inter-cropping with soya beans to be much the most profitable system, while inter-cropping with maize was naturally better than with either of the two leguminous covers.

59. The beneficial effect of inter-cropping with soya beans during the first four rainy seasons as compared with the other treatments is clear, has persisted for four seasons after inter-cropping has ceased, and has given an increase of approximately 30 per cent. in the yield of tung seed over the six year period. Tung on estates has also been observed to do particularly well when inter-cropped with soya during the early years. The effect of soya in this trial, however, is probably liable to be over emphasised unless the conditions of the experiment are borne in mind. The seeds, haulms and part of the root system were removed at harvesting but some of the roots and all the leaves were left, so that the crop probably left the nitrogen content of the soil much as it found it and only caused slight depletion in other nutrients. Cultivation was thorough, and it seems probable that the beneficial effect on the tung was due to the trees getting a good start as a result of this cultivation minimising weed growth and liberating soil nutrients in an available form, rather than to any addition of organic matter or nitrogen. The velvet beans received appreciably less cultivation but they must have added more organic matter and nitrogen to the soil. Quite possibly this crop may not have produced a beneficial effect comparable with that from soya because (*a*) during its growing period, which corresponded roughly with that of the trees, it competed more strongly with the latter than soya, and (*b*) stimulation of tree growth which might have occurred as a result of the added organic matter and nitrogen after cessation of inter-cropping with velvet beans, if it had been followed by fairly clean cultivation, did not occur owing to the competition of grass and weeds, although this was not severe. Similar reasons may account for the poorer results of *Calapogonium* as compared with soya. Inter-cropping with maize, which received about the same amount of cultivation as the soya, occupies an intermediate position, probably because this crop took more out of the soil.

TABLE XXIII. *Mean yields, lbs. dry seed per tree*

Year	Age years	Inter-crop				Sig. diff.	
		Soya	Maize	Velvet bean	Calapo-gonium	P=0.05	P=0.01
		Mean yields, lb. dry seed per tree.					
1944 ...	3¼ ...	4.9	2.3	2.3	1.8	0.63	0.87
1945 ...	4¼ ...	10.1	7.2	6.3	4.8	1.43	1.95
1946 ...	5¼ ...	17.5	11.1	10.2	12.0	1.90	2.63
1947 ...	6¼ ...	17.0	14.4	13.3	11.6	2.38	3.29
1948 ...	7¼ ...	20.8	17.4	16.9	17.7	3.26	4.51
1949 ...	8¼ ...	26.5	24.5	24.0	23.9	N.S.	D.
Mean total '44-'49 ...	...	96.8	77.0	73.0	71.9	11.2	15.5
		Mean girth, inches.					
1948 ...	7½ ...	24.1	22.9	22.0	21.6	1.31	1.81

60. General observations on estates have provided a good deal of evidence to support the view that reasonably thorough cultivation during the first 3 or 4 seasons is particularly important for tung and that failure to give it results in the trees receiving a set-back which it is subsequently difficult to correct. Young plantations which are thoroughly cultivated by inter-cropping with tobacco or soya beans invariably do better than those which merely receive indifferent cultivation as a result of being parcelled out amongst African tenants who are allowed to grow maize and other food crops between the trees, while the latter are usually superior to those in which attention is limited to merely slashing the grass once or twice a year. The beneficial effects of cultivation in reducing weed competition and in rendering the plant nutrients in the soil more readily available to the trees are obviously only to be expected, and no doubt the majority of planters would universally practise a rational system of inter-cropping, by which these objectives would be achieved without marked loss of soil fertility and a profit obtained from the annual inter-crop, were it not for the over-riding factor of shortage of labour. This chronic shortage of labour, which for various reasons cannot in the near future be overcome by mechanisation, gives rise to the problem of finding a system of cultivation which will minimise labour requirements but at the same time permit satisfactory growth of the trees and give good yields and financial returns.

61. With this object in mind an experiment was begun in the 1946-47 season (with trees planted in January, 1945) in which the following treatments are being compared over an initial period of four seasons:

(*a*) Inter-cropped annually with soya beans, the plants being uprooted for threshing and then subsequently spread on the plots and buried.

(*b*) Inter-cropped with a rotation comprising maize, groundnuts, maize, beans; all crop residues buried after harvesting.

(*c*) Inter-cropped with a permanent cover crop of *Glycine javanica*.

(*d*) No inter-cropping and no cultivation beyond circle weeding under branches. Grass and weeds slashed twice a year (January and April) and placed around the trees as a mulch, a dressing of sulphate of ammonia being applied to the trees each season mixed with the first grass mulch. The sulphate of ammonia was applied at 1 lb. per tree (½ cwt. per acre) in the first season (1946–47) and at 2 lb. per tree (1 cwt. per acre) in subsequent seasons.

During the period between the planting of the trees in January, 1945, and the application of the above treatments in October-November, 1945, the only cultivation was circle weeding for a radius of 6 feet around the young trees and the ground between the rows was not hoed or ploughed after clearing. On the first two crops obtained from these young trees there have been no significant differences in yield between treatments; nor do the girth measurements show significant differences in growth. So far, the trees in plots under treatment (*d*) are quite as good in appearance as those in treatments (*a*) and (*b*). It seems probable that the addition of a small dressing of sulphate of ammonia to the grass mulch has made up for the lack of cultivation, and it has been observed that the fertilised mulch rots down very rapidly. On the other hand, the yields and girth measurements from the plots under *Glycine javanica* are lower than from any other treatment, and although the differences are not significant, this fact combined with a rather poorer appearance of the trees, suggests that the undisturbed cover crop may be slightly retarding the development of the young trees.

62. As a subsidiary to the above trial a small experiment was laid down adjoining it in order to compare the effect of the grass mulch with and without the addition of sulphate of ammonia, the treatments being:—
(*a*) inter-cropped with soya beans as in treatment (*a*) of para. 61; (*b*) as treatment (*d*) of para. 61; (*c*) as treatment (*d*) of para. 61, but no sulphate of ammonia applied. The appearance of the grass plot trees without sulphate of ammonia has already indicated a lack of available nitrogen, foliage being less dense than on the other plots and often of poor, yellowish-green colour. The unmanured trees on grass gave significantly lower yields than those in the soya or manured grass plots in 1949 and the 1948 girth measurements for the former were significantly less than those for the latter two treatments.

TABLE XXIV

	Soya	Grass with S/A	Grass unmanured	Sig. diffs.	
				P=0.05	P=0.01
Yield, lb. dry seed per tree, 1949	5.4	5.6	2.9	1.73	2.42
Girth, inches, 1948	11.7	11.9	9.8	1.5	2.1

63. These early results have indicated the beneficial effect of thorough cultivation in the early years, but this presumably involves some sacrifice of soil capital and possibly the initial advantage may become a disadvantage later. There is a suggestion that satisfactory results may be obtained if

cultivation is confined to circle weeding, and the destruction of soil organic matter, &c., thereby reduced, provided that the trees are mulched with grass cut from between the rows and a dressing of nitrogenous fertiliser added, but further results are needed before this can be definitely stated. The indication that permanent cover crops may have some retarding effect on the young trees would, if confirmed, tie up with observations made elsewhere. Thus ROGERS & RATOPOULOUS (1946), and some other workers whose results they review, have noted that during their growth cover crops checked the growth of temperate fruit trees, and although they had a stimulating effect after turning in it took the trees two years to catch up with those which had been clean cultivated. Under tropical conditions in Malaya, HAINES (1933) reported a similar checking effect on the growth of young rubber trees by cover crops of *Crotalaria anagyroides* and *Calapogonium mucunoides*. To obtain more definite information with tung, a more comprehensive and longer term trial, which will compare grass, varying degrees of cultivation, annual green manures and short and long term cover crops, with and without fertiliser, is needed.

Manuring

64. Fertiliser trials, the earliest of which was started in the 1946-47 season, have so far only revealed a response to nitrogen. As might be expected, it has been observed on most soils that quite small application of nitrogenous fertiliser have a marked effect on the early growth of young buddings. The effect on the colour, size and density of the foliage is most marked and trees receiving nitrogen can usually be distinguished from those without it at a glance, but actual girth measurements show a smaller increase than might be expected. This is illustrated by the results obtained from six experimental plots which were planted in January, 1947, in the Vipya area, where the soil is known to be low in n trogen. These blocks, which are scattered over a wide area with a view to observing the growth of tung in a large new potential tung growing area, each compare five treatments: O—unmanured control; N—½lb. sulphate of ammonia per tree; NP—as N plus ½ lb. 18 per cent. superphosphate per tree; NPK—as NP, plus ¼ lb. muriate of potash per tree; D—30 lb. cattle manure per tree. Stronger growth and better foliage were very evident on the plots receiving sulphate of ammonia, and the 1949 girth measurements, adjusted by covariance on the girths immediately below the bud patch at the time of planting, show a significant difference ($p=0.01$) in favour of these plots as compared with those receiving cattle manure or nothing, but the increase, at rather less than 20 per cent., is less than the appearance of the trees suggested (Table 25).

TABLE XXV

	O	D	N	NP	NPK
Mean girth, inches (corrected)	37.1	38.5	44.1	44.0	44.3
Above as % of O	100.0	103.7	118.8	118.6	119.3

65. Trees on estates which have been in bearing for some years, and have often suffered from lack of weed control, have frequently been observed rather rapidly to develop symptoms of nitrogen deficiency in the shape of thin,

uniformly yellowish foliage, marked falling off in yield and, in more severe cases, a good deal of shoot die-back. A rapid response is normally obtained when nitrogenous fertiliser is applied, but when such symptoms have developed it is usually necessary to make annual applications of fertiliser to keep the trees in good condition. The little information so far available, however, suggests that nitrogen may appreciably increase yields from trees which do not show any apparent symptoms of a deficiency of this element. Thus, in a factorial experiment comparing all combinations of presence and absence of nitrogen, phosphate and potash, a significant response to nitrogen applied as 2 lb. of sulphate of ammonia per tree in December, 1946, and 3 lb. per tree annually thereafter, was obtained in 1948 and 1949. (Table 26). The increases in both seasons were considerable, very similar in magnitude and highly significant. Since the fertiliser applied in December, 1948, is unlikely to have affected the 1949 crop (set in October, 1948 and harvested in May, 1949) the increase in yield over the two seasons may be considered to result from a total of 5 lb. per tree of sulphate of ammonia applied in December, 1946, and December, 1947, and on this basis there is a considerable margin of profit per acre, even with these young trees which are by no means in full bearing. Experiments are now in progress to determine the optimum rate and time, or times, of application of nitrogen.

TABLE XXVI

Year	Age	Mean yield lb. dry seed per tree		Sig. diff.		Yield as % O	
		O	N	P=0.05	P=0.05	O	N
1948 ...	4	1.89	2.95	0.13	0.18	100.0	156.1
1949 ...	5	7.74	12.07	1.70	2.23	100.0	155.9

66. Numerous fertiliser experiments with *Aleurites fordii* in America have already shown that with this species nitrogen is the most universally important element and that liberal and frequent applications are necessary for optimum growth and production. It has been found that it increases cross sectional area of trunk, number and total length of shoots per terminal of the previous season (and thus the number of fruiting points), increases the number of female flowers per terminal, and the yield of dry fruit. The size of individual fruits and the percentage of female flowers setting fruit have not been influenced. Nitrogen decreases the percentage of oil in the kernels but increases the percentage of kernel in the fruit, and as the latter usually outweighs the former an increase in the percentage of oil in the whole fruit is normally effected. (BAHRT & POTTER, (1947); LAGASSE & DROSDOFF (1948); PAINTER, DROSDOFF & BROWN, (1948). A single season's records from one experiment with *A. montana* in Nyasaland did not give any indication that nitrogen, at rates of up to 6 lb. of sulphate of ammonia per tree, had any influence on the number and total length of shoots per terminal of the previous season.

67. No responses have yet been obtained to phosphate or potash in any of the fertiliser trials with tung in Nyasaland, but the experiments have not yet run for long and it is possible that application of these elements may later

be found desirable, particularly if increased growth and production are induced by regular nitrogen fertilising. The possibility that applied phosphate may be quickly fixed and rendered unavailable to the trees is being investigated, but the early indication is that the soil of plots receiving superphosphate has a higher content of available phosphate than those without applied superphosphate for at least 5 months after the time of application.

68. Artificial fertilisers are expensive in Nyasaland, owing to high transport costs, but certain materials such as cattle manure, cotton seed, tung press cake and tung husks are available locally at moderate cost and it is desirable that their value as manures for tung be tested. Unfortunately, it has so far been impossible to obtain chemical analyses of these materials in order to assess comparable rates of application and they have been used in only one trial. The 3-year-old trees in the field concerned were distinctly unthrifty and it was merely decided to apply fairly heavy dressings of the manures in a manner which would enable comparisons to be made. The experiment, which comprises 6 randomised blocks of 5 plots each of 10 trees has received the following treatments applied in the months of December, 1946, '47 and '48:—

O—No manure
A—Artificial fertiliser mixture of 2 lbs. sulphate of ammonia, 2 lbs. superphosphate, and 1 lb. muriate of potash per tree.
FYM—200 lbs. cattle manure per tree.
TC—100 lbs. tung press cake per tree.
C.S.—100 lbs. cotton seed per tree.

The manures had no effect in 1947, as might be expected in view of the fact that they were not applied until 3 months after the crop was set. In Table 27 the yields for 1948 and 1949, after adjustment by covariance on the 1947 yields, are shown as a percentage of those from the control plots. Tung cake and cotton seed have given significant increases over control in both seasons but the increase due to artificials is only significant in 1949, and cattle manure has had no significant effect in either year. The amounts of nitrogen applied per tree per annum are probably of the order of: artificials 0.4 lb., cattle manure 1.5 lbs., cotton seed 2.5 lbs., and tung cake 3 lbs. The response to tung cake and cotton seed might therefore have been expected to be greater than that to artificials, but the effect of cattle manure is disappointing.

TABLE XXVII. *Yields as % of yields from unmanured plots*

Year	O	A	FYM	TC	CS
1948 ...	100.0	125.6	116.3	206.4	154.7
1949 ...	100.0	156.6	117.5	145.8	158.4

Conclusions

69. The early results of experiments and observations on cultivation and manuring have so far merely indicated the need for rea onably good cultivation, especially in the early years, and the importance of maintaining adequate

available nitrogen supplies, application of nitrogenous fertilisers or manures being beneficial and probably profitable. Chemical work on the analysis of soils, local manures, leaves and fruit is obviously essential if sound progress is to be made with this kind of work and a study of the effect of fertiliser elements on the oil content of the seeds is likely to be particularly important. Results so far suggest that the system of cultivation likely to prove most satisfactory and profitable would involve thorough cultivation during the first three or four years with an inter-crop which does no make big demands on soil fertility, such as soya beans, followed, as the trees grow bigger and preclude inter-cropping, either by discing of weeds and possibly mulching, or by a permanent leguminous cover crop, such as *Glycine javanica*, which is sufficiently robust to suppress weed growth but not so luxurious as to render it difficult to gather the ripe fruit when it falls from the trees. Such a cover should assist in maintaining the nitrogen status of the soil, particularly if it is disc-harrowed, or shallow disc-ploughed, every 2 or 3 years in order to aerate the soil and incorporate the mass of dead leaves which accumulates, and it may also have a beneficial effect in increasing supplies of available phosphate and potash. Periodic application of nitrogenous manures will almost certainly be necessary in addition, and it is quite possible that in due course phosphate may prove desirable as most of the soils of the tung growing area are low in respect of this element.

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A NOTE ON THE DRAWBAR PERFORMANCE OF A SMALL CRAWLER TRACTOR IN THE FIELD

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Author's Summary

The efficiency of small tractors is mentioned ; the draught and power requirements of some field operations are recorded; and it is suggested that the drawbar performance of a typical six horse-power two-wheel tractor is barely equivalent to that of two oxen. A brief trial of a seven horse-power Crawler tractor is described and it is concluded that in both speed and drawbar performance this machine resembled two to four oxen.

Many small tractors are unable to use the power developed by their engines efficiently for draught. This is due to the difficulty of designing for adequate axle weight and wheel equipment whilst preserving compactness and ease of control. In some, specialization of function allows the engine to be linked efficiently with the work (e.g., rotary cultivator, power mower), but specialization is not always acceptable.

Table I shows the draught of implements on a level, tidy, sand-loam in Trinidad, B.W.I. Table II shows the power developed by animals in work. The draught was measured with a maximum-recording spring balance. The mean was calculated from ten readings, each " averaged " by eye from the vibrating needle.

Table I. *DRAUGHT: Some Field Operations on Sand-Loam*

Operation	Soil Condition	Draught (lb.)		Mean ploughing Resistance (lb./sq. in.)
		Max.	Mean	
Ploughing 9″ x 6″ (inches)	Good	370	220	4
11″ x 7″	Wet; weedy	430	300	4
11″ x 7″	Soft	450	250	3.3
10″ x 8″	Hard	900	700	8.8
Disc Harrowing 8 discs 2	ploughed; hard	260	210	—
8 discs 3	ploughed; hard	420	390	—
Harrowing Chain	ploughed; hard	340	200	—
	ploughed; good	180	140	—
Zig Zag, one leaf	ploughed; good	150	110	—
Wooden	ploughed; good	330	150	—

TABLE II. *POWER—Some Field Operations on Sand-Loam*

Operation	Implement	Source of power	Speed (m.p.h.)	Draught		Power developed at hitch point (h.p.; ft./lb./sec. —550)
				Max.	Mean	
Inter-row cultivation	Horse hoe ...	1 mule ...	2.5	155	120	0.8
Disc Harrowing						
(deep) ...	8-disc ...	2 oxen ...	1.8	390	270	1.3
(shallow) ...	— ...	— ...	2.1	280	160	0.9
Harrowing ...	Heavy wooden harrow 4 times	2 oxen	2	360	250	1.4
Planking ...	Heavy wooden harrow inverted	2 oxen ...	2	290	190	1
Ploughing ...	Swing plough 11″ x 7″	2 oxen ...	1.7	440	320	1.4

Cashmore has stated that a typical 6 b.h.p. two-wheel tractor will pull a maximum of 450 lb. at working speeds. This is roughly equivalent to the maximum pull of two oxen, but it is common knowledge that satisfactory conditions for wheel grip can, in practice, be elusive. It is interesting, therefore, to examine the drawbar performance of a Crawler tractor of about 7 b.h.p. in field work.

The tractor had one forward speed and was driven through a centrifugal clutch. It worked with its own trailer plough; but the measurement of maximum drawbar pull was made against the "dead" load of a tree. No track-slip was recorded, but at 1,100 lb. clutch slip was 100 per cent. (The manufacturers claim a maximum useful pull of 800 lb. It was not convenient during the trial to load the tractor to this point, but it is considered that the claim is modest.)

TABLE III. *The Drawbar Performance of a 7 b.h.p. Crawler Tractor on Dry Sand-Loam in Trinidad*

Speed m.p.h.	Draught (lb.) Max.	Mean	Track-Slip (%)
2.25 ...	—	0	0
2.05 ...	490	185	0
1.95 ...	840	445	0
0 ...	1,100	—	0

Conclusion

In a short field trial of drawbar performance on a dry sand-loam a Crawler tractor of 7 b.h.p. gave a mean drawbar pull, and maintained reserves of power, sufficient to do the work of two, and possibly four, oxen. The tractor moved at about the same speed as oxen.

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THE EFFECT OF SEASON ON THE PROPAGATION OF DERRIS AND LONCHOCARPUS

By

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Summary

Observations on poor rooting of the Sarawak Creeping variety of *Derris elliptica* planted in August, led to an investigation of the seasonal influence on rooting. It was confirmed that poor rooting of this variety resulted from material taken in August. Another variety of *Derris elliptica* and Lonchocarpus were propagated successfully throughout the year, but May was the best time for all varieties.

It has been observed that survival of cuttings of *Derris elliptica* (Wall.) Benth. differs with the variety and with the season of planting. This was demonstrated by experimental work that was started in September 1947, in which unrooted cuttings of both Changi III and Sarawak Creeping varieties of *D. elliptica* were planted directly to the field as recommended by White et al. (1). A high rate of survival was anticipated ; however, only 19 per cent. of the Sarawak Creeping cuttings developed compared with 63 per cent. for the Changi III variety. The high mortality of the Sarawak Creeping cuttings was unexpected and indicated that planting at this time of the year was unfavourable. Since there is a noticeable relationship between the growth flushes of both *Derris* and *Lonchocarpus* and seasonal rainfall, it was thought that this might also be reflected in the survival of cuttings. The growth cycles of *Derris* at this station are as follows : February to May, shedding of leaves, flowering, and fruit set ; May to November, period of active vegetative growth ; and November to February, gradual reduction of growth and dormancy. The growth pattern of *Lonchocarpus* is similar though not as pronounced.

An experiment was started in February 1948 to determine the seasonal effect on the propagation of *Derris elliptica* varieties Changi III and Sarawak Creeping and *Lonchocarpus* sp. (2). One hundred cuttings of each variety were planted every 3 months over a 15-month period. Plantings were made in February, May, August, and November. These dates were selected because in general May to November represents the season of heaviest rainfall and November to May, the lightest (3). Two types of propagating media were used for these tests : sand and clay soil. Twelve-inch woody stem cuttings were placed in the beds at 45° angle, apical bud faced up and covered to a depth of 10 inches. The cuttings were taken at random from the same parent material for all five plantings. Fifty cuttings of each variety were planted

(1) White, D. G., Pagan, C., and Mangual, J. C. The effects of mulching Derris elliptica. *Trop. Agr. (Trinidad)* 24 (10-12) 131-136. 1949.

(2) Believed to be *Lonchocarpus chrysophyllus* Kleinh.

(3) *Puerto Rico (Mayaguez) Fed. Expt. Sta. Rpt.* 1940. (Rear cover.) 1941.

in each propagation media on all planting dates. The beds were watered as often as necessary to maintain adequate soil moisture. One month after planting, a complete fertilizer was applied to the plants grown in the sand bed. Three months after planting the cuttings were carefully spaded out and the number of live plants recorded. The roots and tops were removed, dried and weighed. These data are presented in Table 1.

TABLE I. *The effect of time of year on the propagation of* Derris elliptica *and* Lonchocarpus

Species	Planting date	Soil				Sand			
		Survival from 50 cuttings	Average dry weights per plant		Ratio tops	Survival from 50 cuttings	Average dry weights per plant		Ratio tops
			Tops	Roots	Roots		Tops	Roots	Roots
		%	*Gms.*	*Gms.*		%	*Gms.*	*Gms.*	
Derris elliptica var. Sarawak Creeping	Feb. 1948	66	—	—	—	86	—	—	—
	May 1948	84	1.4	0.26	5.4	90	2.0	0.25	8.0
	Aug. 1948	16	.6	.04	15.0	8	.2	.05	5.0
	Nov. 1948	46	.8	.02	40.0	62	1.0	.06	17.0
	Feb. 1949	70	.5	.02	25.0	100	1.3	.13	10.0
D. elliptica var. Changi III	Feb. 1948	66	—	—	—	94	—	—	—
	May 1948	100	1.2	.22	5.4	100	2.0	.28	7.1
	Aug. 1948	88	2.8	.30	9.3	100	1.3	.07	18.5
	Nov. 1948	100	.6	.05	12.0	98	1.5	.23	6.5
	Feb. 1949	98	1.8	.14	12.8	100	4.2	.30	14.0
Lonchocarpus spp.	Feb. 1948	50	—	—	—	80	—	—	—
	May 1948	86	.7	.13	5.3	88	1.2	.21	5.7
	Aug. 1948	72	1.1	.04	27.5	96	2.2	.09	35.5
	Nov. 1948	78	.7	.05	14.0	82	2.2	.16	13.8
	Feb. 1949	78	.9	.05	18.0	92	1.8	.13	13.8

The survival of the Sarawak Creeping cuttings planted in August was significantly lower than that obtained at any of the other dates. 16 per cent. of these cuttings survived in soil and 8 per cent. in sand. These data confirmed the observations made the preceding year which showed that August to September plantings of this variety were unsatisfactory. The other variety of *Derris elliptica* and the *Lonchocarpus* spp. were propagated successfully throughout the entire year. The percentage of survival of all cuttings was slightly higher in the sand than in the soil.

However, May was the best time of the year for propagation of all species and varieties on the basis of root production and favourable top-to-root ratio.

A summary of the results shows that the season of propagation had a distinct and different effect on survival and growth of cuttings of *Derris elliptica* varieties Sarawak Creeping and Changi III and *Lonchocarpus* spp., Sarawak Creeping cuttings could not be successfully propagated during the August to September period. The survival of cuttings of the Changi III variety of *Derris* and of *Lonchocarpus* spp. was uniformly high throughout the year, although May was the best time of the year for propagation of both species, when root growth and favorable top-to-root ratio are used as criteria.

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FLOWERING INDUCED ON DERRIS ELLIPTICA

By

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Summary

Evidence is presented to show that the flowering of *Derris elliptica* is favoured by trellising the plants in full sunlight. Trellising results in vigorous plants well exposed to light which at a suitable age, flower freely.

For the first time at this station all three varieties of *Derris elliptica* (Wall.) Benth., Changi III, St. Croix, and Sarawak Creeping, flowered simultaneously. The first flowers appeared in the latter part of February and the plants continued to bloom through April. The period of florescence was about equal for all three varieties. Although the Changi III plant had the heaviest florescence, only 3 or 4 seed pods developed. The St. Croix plant had 50 or more seed pods while over a hundred pods were counted on the Sarawak Creeping plant. Last year the Changi III and Sarawak Creeping plants flowered for the first time and the latter set a few seed pods. These pods were bagged so that the seeds could be recovered and tested for viability. Although most of the seed pods were lost through vandalism, the few that were recovered failed to germinate. It is hoped that some viable seeds will be obtained this year.

As has been indicated in a previous report (1) the Changi III variety produces flowers annually under normal conditions: however, special cultural care must be taken to induce flowering in the Sarawak Creeping and St. Croix varieties. In December 1944 individual plants of each of the three varieties were placed in soil-filled 5-gallon oil tins and grown for 4 years under green house conditions. Although the stems of all the plants were girdled and slashed these efforts did not induce flowering. In February 1948 these plants were transplanted to a station field and the vines trellised. The trellises were made by stringing wire horizontally at a height of 7 feet between bucare stakes. The plants were placed in an open area where they would be exposed to full sunlight throughout the day. Each plant was ring fertilized with a quarter of a pound of complete fertilizer every 6 months after transplanting. The plants responded well and all are growing with exceptional vigor.

At the same time that these three plants were transplanted to the field a single Sarawak Creeping plant that had grown for 5 years in the same area was trellised in a similar manner. This plant was one of a series of border plants that had been left from a propagation experiment (2). The trellised

(1) *Puerto Rico (Mayaguez) Fed. Expt. Sta. Rpt.* 1948 : 5. 1949.

(2) White, D. G., Pagan, C., and Jones, M. A. Production of *Derris elliptica* in relation to type of cutting and age at harvest. *Jour. Afr. Res.* 77(1) : 13-24. 1948.

plant flowered for the first time last year and again this year while none of the untrellised plants have blossomed. This plant is also well developed and has a main trunk of over an inch in diameter.

A few Sarawak Creeping plants grown on a small trellis in partial shade for over 8 years have never been observed to flower. These plants are crowded and this competition has reduced their growth and vigor. In other experiments (3, 4) conducted at this station trellised plants were much more vigorous than untrellised plants. It is known that light plays an important rôle in floral production. Trellising the plant exposes a greater leaf area to sunlight which may induce the plant to bloom.

From these observations it would seem that trellising, vigor, light, and age are factors in inducing floral production in *Derris elliptica*. Trellising is perhaps the most important as it exerts a direct influence on both vigor and light.

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(3) *Puerto Rico (Mayaguez) Fed. Expt. Sta. Rpt.* 1940 ; 38-39. 1941.
(4) *Puerto Rico (Mayaguez) Fed. Expt. Sta. Rpt.* 1949 : 6. 1949.

WEST INDIAN CACAO RESEARCH—A PROGRESS REPORT*

By

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Summary

This article is a brief review of the history and progress of the Cacao Reserved Scheme since its inception at the College.

Cacao, cultivated strictly within the tropics and mainly at low altitudes, has reached a period of transition when the old methods are being abandoned and their place taken by more productive techniques. By the old methods is meant the cultivation of seedling cacao on an extensive scale, with or without shade. Even with careful management, yields were relatively low, 500 lb. of dry cacao per acre per annum being considered good. By modern methods it meant intensive orchard cultivation involving, in order to obtain much higher yields of 1,000 lb. or more, the selection of high bearing trees, vegetative propagation, correct manuring and the control of diseases and pests. During the last thirty years, cacao cultivations in many parts of the tropics have failed or declined because of uneconomic low yields, low prices in the depression years causing neglect, old age of the plantations and diseases and pests. At present the world supply is barely meeting the demand, and unless this decline is checked, there will soon be a definite shortage.

The chocolate manufacturers recognize three main types of cacao:

1. The bulk crop of West Africa and Brazil, which forms a high percentage of the world's cacao but commands the lowest price.
2. Cacaos of intermediate quality, such as are produced in Trinidad and Grenada, commanding a premium over West African cacao.
3. The high quality, high priced Criollo cacaos, such as Venezuelan Criollo, which are only produced in small quantities and are tending to disappear altogether.

The West Indian Cacao Research Scheme was started in Trinidad some twenty years ago to try to improve the yields and quality of cacao produced in the West Indies. More recently cacao research schemes have been started in West Africa, with the primary object of controlling swollen shoot disease and certain insect pests; and at Turrialba in Costa Rica, where the primary objectives are general research work and the training of Latin American students in cacao cultivation. The economic side of cacao production has also been studied for many years at the Imperial College in Trinidad.

During the last two or three years the scope of the West Indian Cacao Research Scheme in Trinidad has been considerably expanded. This scheme,

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*A talk given to the Society of Professional Agriculturists in Jamaica on 14th July, 1950.

which is to run for a ten year period, when fully staffed will employ two plant breeders, two plant physiologists, a mycologist and an entomologist, two soil chemists and a biochemist, and a field manager at River Estate. It is administered by the Principal of the Imperial College, through the Professors of Chemistry and Botany, who are responsible for their respective sections. At present four out of the total of ten staff are at work including the senior plant breeder and senior physiologist. At least three of the vacancies will be filled in the next few months. After working with us for two years, the biochemist has left to join the staff of the Ceylon Tea Research Institute. Other members of the Imperial College staff have for many years devoted much of their time to cacao problems.

Under the direction of Dr. E. E. Cheesman, then Professor of Botany at the College, the Cacao Research Scheme first turned its attention, in 1930, to the selection of improved strains and to vegetative propagation. The late Dr. F. J. Pound examined many thousands of trees and finally selected for further propagation 100, now known as the Imperial College Selections or I.C.S. clones. These trees were primarily selected for high yield, using the criteria of number of pods per tree per annum corrected for size of tree and the quantity of wet cacao per pod. Actual size of pod is relatively unimportant as there are great differences in the thickness of the shell; it is the size of the cavity inside which is important. The success of his selections is demonstrated by the excellent yields of over 1,000 lb. of dry cacao per acre which some of these clones are now giving.

At the same time an attempt was made to select for quality and attention was paid to trees which produced large plump beans and light coloured or even white cotyledons as opposed to small flat beans with dark purple cotyledons.

Unfortunately, manufacturers' reports on samples of cacao prepared from some of our clones have been disappointing and it is obvious that there is more in the production of quality cacao than a simple selection of this nature. Cacao from monoclone blocks of a single variety will not reproduce the flavour of the old seedling population. Fermentation and preparation are also of great importance and may play a big part in developing the typical flavours prized by the manufacturers.

In later years, after he had joined the Trinidad Department of Agriculture, Dr. Pound visited South America on several occasions in search of cacaos resistant to witches' broom disease. Two at least of the plants he brought back, now called SCA 6 and SCA 12 are apparently immune to the disease, although opinion is divided on their yielding power and quality.

Other selections have been made, for example, for thrips resistance, and cacaos have been collected from Central America by Mr. G. E. L. Spencer, now manager of River Estate. Attempts are also being made to obtain a representative collection of wild *Theobroma* species and a collecting expedition to the headwaters of the Orinoco is under consideration.

Genetical studies on the inheritance of sterility and other factors have been started by Mr. Cope, who is also making crosses among the I.C. Selections and the witches' broom disease resistant varieties. The object of this

work is to produce clones which will be more efficient than those now in existence, but progress will inevitably be slow as a cacao tree takes three or four years to come into bearing.

Much time has been spent by Dr. Cheesman, Mr. Voelcker (first director of the West African Cacao Research Institute; now Director of Agriculture, Malaya), Dr. Dodds, Mr. Cope and others on the study of the behaviour of the 100 I.C. Selections in field trials. Here we have been very greatly helped by the late Mr. Robert de Verteuil, a most enlightened Trinidad cacao planter, whose recent sudden death is deeply regretted. Old students of the College will remember his excellent demonstrations at the San Juan Estate.

Owing to the generosity of certain British chocolate manufacturers we have been able to obtain possession of the buildings and some 350 acres of River Estate for our cacao experiments. Here and elsewhere many of the 100 I.C.S. clones have been under observation for some years and a mass of information has accumulated.

For example, although all were selected as high yielders, not all have done well in these trials, and a would be expected, many of the self-compatible clones (those which set pods when fertilized with their own pollen) are amongst the best bearers. Certain self-incompatible clones, however, such as I.C.S. 39, 40 and 60 are also magnificent bearers. Differences in toleration to poor conditions, to cacao beetles and thrips, and in susceptibility to witches' broom disease have also appeared.

Consideration of all this information has enabled us to recommend with some confidence certain clones for general distribution, such as I.C.S. 1, 6, 8, 39, 40, 45, 60 and 95, all of which have been established in a diseased free nursery in St. Vincent to that they can be sent to other countries without the risk of spreading the cacao virus disease and witches' broom disease which occur in Trinidad.

Planters have been urged not to plant monoclone blocks on their estates and to take at least five clones as a mixture for replanting a field as even on different Trinidad soils different performances have been recorded. Needless to say other countries have been warned that these Trinidad selections may behave very differently elsewhere.

Turning to methods of vegetative propagation, it has been known for many years that cacao can be propagated as rooted cuttings, by budding and also by grafting. The late Mr. E. E. Pyke and Mr. G. E. L. Spencer, now manager at River Estate set themselves in the 1930's to work out a commercially possible technique for producing plants in large quantities.

After some years they showed that the only feasible method was the use of semi-hardwood fan cuttings raised in the now familiar propagating bins.

This method has been put into use on a large scale in Trinidad and during the last twelve months the La Pastora propagating station has raised the very creditable total of 250,000 cuttings of high yielding clones for distribution.

This brings us to the present time; what of the future ?

Firstly, starting in 1949, a very complex series of experiments devised by Professor Hardy, Dr. Dodds and Mr. Cope are being planted at River Estate. The largest of these, which covers eleven acres, is probably the largest cacao experiment in the world, and is designed to study the effects

of shade and no shade, close and wide spacing, N, P and K manuring and all their interactions. The whole experiment is planted with I.C.S. 1 and individual yields must be kept for some 6,000 trees, no small task in itself.

Smaller experiments have been planned to compare the effect of leguminous and non-leguminous shade trees ; mechanical intercultivation with Grenada forking and no cultivation ; and mulching with bagasse or cut bush against no mulch. Lastly we propose to lay down as soon as possible a variety trial to compare all the more promising selections and it is hoped that this experiment will be replicated in many parts of Trinidad on different soil types and under different climatic conditions.

Studies in the control of witches' broom disease have been in progress at the College for some years and are being continued now that the Research Scheme has its own mycologist, Mr. Holliday.

The cacao virus, which resembles in many respects a mild strain of the West African swollen shoot disease is being investigated particularly by Professor Kirkpatrick.

An important part of the Research Scheme is that of the Plant Physiologists. Dr. Evans, with the help in recent months of Dr. E. J. Maskell of the Plant Physiology Department of the Cambridge Botany School, has now surveyed the problems and proposes to concentrate his efforts on the effect of shade on the growth and yield of cacao trees; on manuring, with particular reference to trace element deficiencies, which are widespread in Trinidad and Grenada, on root studies ; and on the improvement of methods of vegetative propagation. The first three of these are long range projects, which cannot be expected to give results for some years, but the improvement in the technique of vegetative propagation is of more immediate application.

The method at present in use is difficult, expensive and wasteful of nursery material. For example, of the cuttings taken at La Pastora only some 55 per cent. reach the field; the remainder are lost for a variety of reasons. Moreover, all of these are large stem cuttings, necessitating the maintenance of very extensive nurseries from which nearly 50 per cent. of the material taken is wasted.

Dr. Evans and Mr. Constable of the Trinidad Cocoa Board are attempting with considerable success, to reduce this wastage of nursery material and thereby increase their output.

The lines along which they are working are firstly a reduction in the size of cuttings from stem cuttings with 8 or 9 leaves to single leaf cuttings; the use of simpler propagators which will hold more plants per unit area ; the best use of rooting hormones ; the correct control of shade in the nursery and of light, temperature and water in the propagators; and the preparation of the best possible potting compost to give rapid growth.

It is safe to say that within a year or two, much improved methods will have been developed.

In conclusion it must be emphasised that cacao cultivation requires a high degree of horticultural knowledge and skill and should not be lightly undertaken. Nowhere is this need for a high degree of skill more evident than in the technique of vegetative propagation as is demonstrated by the very poor results so often obtained by those with insufficient knowledge.

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AN UNUSUAL PROBLEM IN LAND CLEARING

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Authors' Summary

A Caterpillar D.7 tractor with an angledozer was used to clear an old bamboo plantation. Factors affecting the clearing are discussed.

In the first dry season 50 acres were cleared. The operations of uprooting, burning and disposing of the bamboo, rough levelling and drainage are described ; an early estimate of the operating cost is given. The clearing of an additional 17 acres during the wet season 1948, could not be completed. An unusually wet dry-season hindered operations in 1950.

It was found that two years were required completely to dispose of the bamboo stools. The formation of broad cambered beds on the cleared land with the angledozer is described, and the actual cost of operating the tractor over 27 months is given.

The bulldozer has been called a shameful agricultural implement, but in work being carried out by the Imperial College of Tropical Agriculture, Trinidad, a Caterpillar D.7 tractor fitted with an angledozer is proving very successful in handling the unusual problem of clearing a large area of land which has for twenty years been under bamboo (*Bambusa vulgaris*). The bamboo was cultivated on plantation lines by a well-known firm whose intention was to manufacture paper on the site. Commercially the project failed and after the war the manufacturing plant was dismantled. Part of the estate has been made available to the College for development as a farm.

The bamboo is at various stages of growth, the individual shoots being up to sixty feet in height (probably averaging about forty-five feet). The shoots grow in clumps from four feet to twelve feet in diameter and emanate from one massive stool which is firmly anchored by a mass of fibrous roots.

The problem of clearing the land is complicated by several factors arising out of local conditions :

1. The bamboo is growing on steeply cambered beds (resembling the local sugar-cane beds) eighteen feet wide and separated by deep drains. Several shallow " ravines " or natural flood-water courses traverse the area.
2. The soil itself is unusually sandy for Trinidad. A thick carpet of bamboo leaves has collected on the surface and it is desired to preserve as much of this organic matter as possible, yet owing to their huge bulk, burning seems to be the only practicable way of removing the woody stems.

3. Owing to the spasmodic and often torrential rainfall large-scale mechanical operations cannot be undertaken safely during most of the wet season which lasts from June to December, since the land could rapidly be turned into a morass.
4. Since burning is the only available method of disposal for the bamboo most of the felling must be done in the dry period from January to May; it is seldom possible to make a satisfactory burn during the wet weather.
5. The climate and ecology of Trinidad are such that virtually nothing grows during the dry season (unless it is watered), but as soon as the rains begin a mass of vegetation springs up on uncovered land. This means that the felled bamboo must be quickly removed before rain encourages a tangle of plants to grow through it.
6. Finally, local prices are high and a quotation for the clearing by a local (non-agricultural) contractor was beyond contemplation.

It was decided to make an initial capital outlay on the purchase of the D.7 Caterpillar, the intentions being (1) that a large part of the outlay should be recovered by sale of the equipment locally after a few seasons' work, and (2) that being under direct control, the work could proceed at the most advantageous time, by the most agriculturally suitable method. A highly skilled East Indian operator was engaged and—a sidelight on West Indian conditions—a service-man and night watchman had to be employed.

Fifty acres were scheduled for clearing in the first season. Work started on February 2nd, 1948, and finished on May 31st. After a certain amount of trial and error a method was adopted which involved the minimum of earth-moving. As the operator settled to the work he was able to fell more than two acres per day. The tractor worked with an angled blade, the throw being, say, to the north. Facing west, the operator moved backwards from clump to clump along one bed at a time. Taking each clump from the east he struck the bamboo poles with the blade two or three feet above the ground and as the tractor started to " climb " the clump he swung the tractor to the north. This usually uprooted the clump and threw it down to the north-west. By tamping the roots with the blade the operator then moved the fallen clump bodily forward, stems first, to clear the ground for the next stool. In this way, regularity was achieved so that the work could be more easily controlled and an orderly array of bamboos was left drying in the sun. As each block of about eight acres was felled, the bulldozer cleared fire traces around the outside.

After three weeks drying the blocks were fired. The bamboo burnt like tinder leaving only charred stumps and stools. The tractor returned to push the stools up into large banks. The banks then occupied about four of the fifty acres.

A certain amount of the top-soil then had to be moved slightly in the rough levelling which was done in top gear with a flat blade. This smoothed out what remained of the inter-bed drains.

There remained the problem of the flood drains or " ravines " which had been choked by the tractor. These were reconstructed as broad shallow U drains which could be traversed by mechanical equipment. This was done

with an angled and pitched blade. Disc harrows were pulled across the drain to smooth off the sharpness of the bulldozer's cut. Subsequent experience showed that only during the driest weather could equipment cross these drains satisfactorily and that the churning of the soil in the drain inverts impeded the waterflow and encouraged wet-land weeds. The policy was changed to allow of the use of these water courses as field boundaries where possible, and elsewhere to realign them so that they were as nearly as possible parallel to the direction of mechanical operations. The angledozer formed satisfactory "ravines" up to four feet deep in four bouts. An additional two bouts were required to dispose of the spoil over the neighbouring land.

At the end of May the rains arrived and the D.7 was laid off. The banks of stumps were quickly planted with pumpkins and okras which effectively prevented sprouting of bamboo or serious weed growth, and the new land was quickly planted with an annual crop or with grass to prevent weed growth and soil erosion. Subsequent inspection showed that only in two small blocks of land which were originally uneven had the bulldozer seriously moved the topsoil.

At the close of the first season's operations fifty acres had been cleared in ideal weather and the following summary of the costs was presented. The estimate of the cost of operating the D-7 was based upon the supposition that over the life of the machine several very expensive overhauls would be necessary. It was anticipated that the tractor would work for 1,000 hours per year and that an average of $2,000 per year would be spent on repairs and overhauls.

The outlay on capital equipment was about $17,000 (£3,500) and for purposes of depreciation the life of the tractor was taken as ten years. Interest on capital was allowed at 3 per cent. of the depreciating value, and allowances were made for housing, repairs, &c. The operator was paid $4.50 per ten hour day, the serviceman $2.00 per day and the watchman $1.50 per night. The daily labour bill was therefore $8.00. Gasolene cost 35 cents per gallon and dieselene 22 cents. The cost of working the tractor for one day was estimated to be $63.00. The current local hire charge for similar equipment was $120.00 per day.

Estimated overall cost per acre of clearing cultivated bamboo (1948)

Overheads ... ... (B.W.I.)	$37
Felling (net)	17
Burning, banking, rough levelling, &c. ...	40
Total cost per acre	$94 (£19. 12s.)

In September–October, 1948, an attempt was made to clear an additional seventeen acres. In Trinidad a brief dry spell is said to occur at this time of year. It was not possible to burn the fallen bamboo, which had to be pushed into windows to dry. A few acres could not be windrowed owing to increasing rainfall, and they remained in a tangle of bamboo and weeds until early in 1949. No further effort has been made to clear land out of the dry season.

Owing to staffing difficulties only about 10 acres were cleared in 1949. The tractor was used mainly to realign several of the banks of decomposing stumps which were standing over from the previous year and to clear land for neighbours. Much of the material had rotted down after twelve months under pumkins and okras. The unrotted parts were pushed on to graded contours and above each new bank a shallow U drain was cut. These drains were approximately two hundred feet apart and no other drainage was provided. Towards the end of the year much of the land became waterlogged and it was decided that during 1950, along with the disposal of the remaining banks, the land scheduled as arable should be laid out in broad cambered beds of uniform width. The average grade of the interbed drains for any one field was to be as nearly as possible ¾ of 1 per cent.

The dry season of 1950 was catchy, and the bulldozer in pressing on towards a target of 100 acres clearing reached only 49 acres before a halt was prudently called. Showers continually delayed the burning of the fallen bamboo, and only about 34 acres were satisfactorily cleared before the onset of the rains early in June. The tractor was able to proceed with the realignment of the land already cleared and the spreading of more banks of valuable organic matter. The banks on a section cleared in 1948 were finally spread by the bulldozer early in 1950. Very few large roots remained, and the section was then considered to be completely cleared.

Before the long-term cropping plans were put into effect the section was put into cambered beds at 45 feet centres. A brief trial was made to form the beds with a Fordson Major tractor and a F-R mounted, 2-furrow, semi-digger plough, but it was found that :—

(*a*) sufficient small stumps still remained in the land to be a danger to ploughshares, and no spare share was available locally;

(*b*) at least three ploughings were necessary to form even a slight camber, and after this treatment the soi had become very finely pulverised ;

(*c*) at best the rate of work was about ¾ acre per day.

The angledozer was brought into use again, and after trial, and a little error, it was found that a shallow, flat-topped bed could be formed in three bouts, two in the drain and one on the spoil. If time permitted, a disc ploughing helped form a slight crest on the bed. The only disc plough available was a single-furrow sulky (drawn by a Fordson Major), so very few beds were ploughed. These shallow beds were used for annual crops, the intention being that in 1951 they should be raised, probably by ploughing, at a more leisurely time. Fully cambered beds at 45 feet centres could be formed in nine to twelve bouts with the angledozer. Such beds were made where land was to be put under sugar cane or fodder grass, and it was not anticipated that any major operation would be undertaken for four years.

In 27 months the Caterpillar D.7 has worked for 3,400 engine hours. It has had one routine overhaul and has cost (in fuel, lubricants, spare parts and minor repairs) $5,531.89 or $1.63 per hour. When it was new it used 20–23 gallons of fuel per day of 10 hours; it now uses 28–30 gallons. The operator is now paid $5.20 per day, and the serviceman $2.62. The watchman is no longer charged to the tractor. The cost of working the tractor for one

day over this period has been $30.24, or $3.78 per hour. It must be remembered that very heavy repair bills have not yet been incurred, but it is expected that expenses will steadily rise, especially after 5,000 hours has been passed, and the earlier estimate of $63.00 per day will probably be justified.

The following table shows the rates and costs of certain operations. The costs are based on the actual operating expenses in 1948–1950, plus depreciation, interest, housing and wages. The final costs of the whole project will depend very largely upon the resale value of the equipment when the work is completed. The "artificial" conditions of the dollar shortage may increase the resale value significantly.

Rates and Costs of Work ; Caterpillar D.7 Tractor with Angledozer clearing cultivated bamboo in Trinidad, B.W.I. Cost $30.24 per day.

Operation	*Rate acres/day*	*Cost per acre* $1.00 *B.W.I.*=4*s.* 2*d.*
Felling bamboo	2½–3	$10.08–$12.10
Fire tracing, and banking burnt stumps	3	$10.08
Rough levelling and final stumping	3	$10.08
Opening shallow " V " drains (6 cuts)	800 feet/hour	
Forming fully cambered beds at 45 feet centres (18 cuts) ...	3–3½ 300 feet/hour	$8.64–$10.08
Clearing operations ; standing bamboo to planting on shallow beds in 1 season ; overall ...	2/3	$45.36

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OBITUARY

JAMES GORDON MILLER

By the death on September 11th at his home in Scotland of Mr. James Gordon Miller, a member of the Governing Body since 1941 and of the Finance Committee since 1942, the Imperial College of Tropical Agriculture has suffered a grievous loss. We shall long remember this trusted counsellor, generous benefactor and great friend. On his visits to Trinidad, despite other claims on his time, he gave those of the College high priority. His interest in all its affairs was profound but perhaps his warm nature found its highest satisfaction in personal contacts with both students and staff. We remember with pleasure the excursions to Caroni that he arranged. We recall with particular gratitude the personal contributions which he made to the general funds of the College and the Gordon Miller Trust which he created, giving five thousand pounds as the nucleus of a fund for the welfare of the scientific and administrative staff of the College.

The College mourns, but it does not mourn alone. Mr. Gordon Miller had wide interests. In his early days he was engaged in the nitrate trade and then in shipping and merchants business. Since 1937 he had been chairman of Caroni Limited, the third in succession of the sugar producing companies of which he was director and which finally brought under one control the Caroni, Brechin Castle and Lothians sugar plantations as well as those that formerly belonged to Waterloo Sugar Estates (Trinidad) Limited. He had other business directorships, and his public activities were numerous. He worked with enthusiasm to secure adequate representation of the British West Indies at the Glasgow Exhibition in 1938 and bore the lion's share of the expense of that effort. He was a member for twenty-three years of the Executive Committee of the West India Committee and a vice-president and former chairman and vice-chairman of that body, as well as chairman of the Trinidad and Tobago Standing Committee. He was a member of the Colonial Sugar Committee, a director of the West India Association of Glasgow and vice-president of the West Indian Club. He was a member of various deputations to the Colonial Office in connexion with the West Indian sugar industry and he gave evidence before various official bodies, including the Royal Commission that visited the West Indies in 1938, and the Imperial Shipping Committee in 1939. He also represented the Associated Chambers of Commerce of the British West Indies at the fifteenth congress of the Federation of Chambers of Commerce of the British Empire in London in 1939.

The College circle and the wider world of West Indian affairs alike are the poorer for the passing of James Gordon Miller. Worthy of special mention was his devotion to the younger generation. There are many today who have cause to be grateful for the kind and patient interest he displayed in their early careers. A wise man, a man of integrity, throughout the course of a full life he had the touch that endeared him to all.

To Mrs. Gordon Miller and relatives we offer our very sincere sympathy.

A.E.V.B.